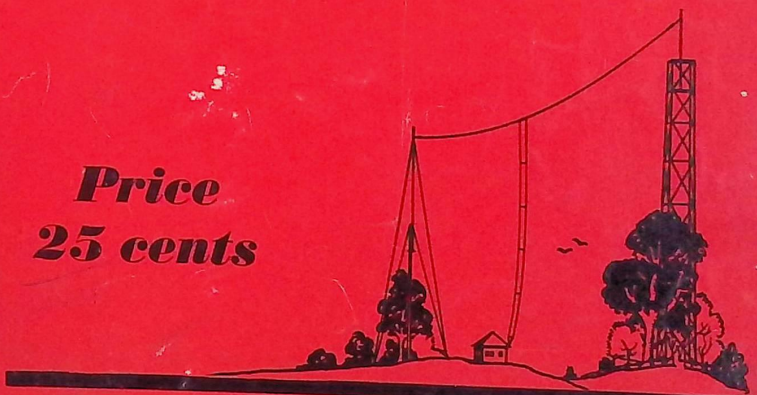
SEVENTH EDITION

The Radio Amateur's LICENSE MANUAL

How to Get Your Licenses —Including Complete Questions and Answers for Class A, B and C Examinations



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THE RADIO AMATEUR'S

LICENSE MANUAL

TO OWN and operate an amateur radio transmitting station in the United States it is necessary to have two licenses, both of which are issued by the Federal Communications Commission, at Washington, D. C. For the operator himself there is the *operator's license*, issued after the individual has passed a code test and a written examination designed to test his familiarity with radio law and regulations and his knowledge of the proper operation of amateur transmitting equipment; the holder of an operator license can operate any amateur station, his own or someone else's (subject to the regulations, of course). For the transmitting equipment itself there is the *station license*, which licenses the operation of one particular collection of transmitting equipment at a specified location.

It is absolutely essential that both licenses be obtained before an amateur station of any kind can be operated. We wish to emphasize this point and, further, to emphasize that there are no exceptions to the requirement for licenses. Those who, after study, think that the language of the law is such as to permit of some special interpretation which will enable unlicensed operation under certain conditions are warned that the language of the law is air-tight, and no such special interpretations are possible. Please do not write us, therefore, asking if unlicensed operation isn't all right if the power used is so low that the station won't be heard over the state line, or if licenses are required for five-meter transceivers, or anything of that sort; you will only be wasting your time and ours. To make it perfectly clear, we will repeat that under no circumstances can any sort of radio transmitting equipment be operated without a station license for the equipment and an operator license for the operator. If we appear to be stressing this point unduly, it is only because, in spite of all we say, several hundred individuals each year read these words and then write us asking if licenses are necessary in this special case or that. There are no special cases; licenses are *always* necessary. The loss of future operating privileges as well as the prospect of fine and imprisonment face the unlicensed operator who is sure *he* is an exception.

There is no age limit for amateurs. However, only American citizens can own and operate amateur stations in the United States. Under our present national policy it is not possible for aliens to do so. Since aliens possessing first papers are not yet full-fledged citizens, they also are barred from holding licenses.

The Combination Station-Operator License

In its physical form, the amateur license is a slip of heavy white paper about 3 inches by 5 inches. This contains both the station and operator licenses, the station license appearing on one side and the operator license appearing on the reverse side. It is not necessary to post this license in your radio room but it is required that you have it in your personal possession whenever you are operating. Be sure to take it along with you whenever you happen to be operating some station other than your own; the station license part of it is no good to you under these circumstances, of course, but you need it for the operator authorization. If your station is going to be operated by someone in your absence, either leave your license at your station or have a photostat copy of the *station* authorization made and post that in your shack.

Most people getting licenses intend to have stations of their own and therefore obtain both station and operator licenses. However, a person wishing to get only an operator license can do so; simply state you want the operator license only, and leave blank all portions of the application form with respect to the station-license application. It should be mentioned, though, that it is impossible to get a *station* license alone, without at the same time getting an operator license; it is required that a person who wants an amateur station license must also qualify as an amateur operator.

Moreover, only an *amateur* operator may operate amateur stations, and even the holder of a "commercial" must obtain an amateur operator license, in addition, if he wishes to operate an amateur station.

The Station License

The station-license part of the combined license is the station's "registration." It licenses a collection of apparatus at a particular address (with portable privileges, however) to be operated as an amateur station in the amateur frequency bands. It designates the official call to be used. It is secured by filling in those portions of the combined license-application form which deal particularly with the station-license application.

Station licenses will not be issued where the property on which the station is to be located is controlled by an alien. If you are an American citizen and own your own home, you may have a station there. If you are a citizen, renting the house or apartment where you live, you may have a station even though the actual owner from whom you rent is an alien. Your rental of the property brings it under your control. On the other hand, if you are merely boarding with a

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family of aliens, or if your parents or your guardians are aliens and are the actual owners or renters of the property where you live, you cannot get a station license for that location even though you yourself are a citizen. The premises in both the latter cases are controlled by aliens.

The station license runs concurrently with the operator license and like the latter has a term of three years. It may be renewed, as will be outlined later.

Portable Operation

The possession of a station license automatically authorizes you to operate a portable station in any amateur frequency band, without the necessity for any special portable license, provided you comply carefully with Rules 221, 384 and 387, as published near the conclusion of this booklet. Portable-mobile operation (from aircraft, automobiles, boats, etc.) is not permitted in any of the lower-frequency bands, but may be engaged in on amateur frequencies above 28,000 kc., as outlined in Rule 368. Logs must be kept in all cases, of course.

Be sure to have your combination license with you when operating portable equipment under your own call. If not operating your own portable equipment, be sure that you have with you either the original combination license for the call under which the portable equipment is being operated, or a photostat copy of the station authorization for that call. This, of course, is in addition to your own operator license, which you must also have with you. If you have a portable station operating under your call but not being operated by yourself, see to it that whoever is doing the operating has either your combination license or a photostat of the station authorization with him. You should also be sure such operator is licensed and has his own amateur operator license with him, since you are legally responsible for the proper operation of equipment being operated under your call.

Do not operate another person's equipment or station under your call, even as a "portable"; your call and your station license apply only to your own equipment and cannot be used in connection with the equipment of someone else. In such circumstances, always use his call, and see to it that his station license or a photostat copy of it is in the operating room.

The Operator License

The operator authorization on the combined license testifies to the holder's ability to operate an amateur station — not only his own station but any amateur station. A person who wishes only an operator license may obtain it, even if he personally does not own a station, by filling out only those portions of the application form dealing with the operator ticket.

To determine that the applicant has the requisite ability the government requires that he pass a written examination (in addition to filling out the application form) to show that he is familiar with simple radio theory, operation and adjustment of basic transmitting equipment, both telegraph and 'phone, and with the essential parts of the radio law and regulations. The written examination consists of ten questions selected from an extensive list prepared by the Federal Communications Commission; the questions and answers in this booklet indicate their nature and scope. It is also required that the applicant demonstrate ability to send and receive Continental Morse code at the rate of thirteen words per minute (five letters to the word). That the applicant intends to use 'phone rather than telegraphy does not excuse him from this code test; everybody has to take it.

Learning the code is mostly a matter of practice. Hints on learning it, data on buzzer practice sets, instructions on properly handling a transmitting key, etc., are contained both in *How to Become a Radio Amateur* (25¢) and in Chapter II of *The Radio Amateur's Handbook* ($1.00), obtainable postpaid from American Radio Relay League, West Hartford, Conn.

Like the station license, with which it is combined and concurrent, the operator license runs for a period of three years.

There are three classes of amateur operator license but two of these are substantially identical in effect, so that it is easier to consider that there are two grades. The *Class A* is the advanced grade, sometimes referred to as the "unlimited 'phone" license since, in addition to carrying the privileges authorized under the *B* and *C* licenses, it enables the holder to operate 'phone in the two restricted bands 3,900–4,000 kc. and 14,150–14,250 kc.

The *Class-B* and *Class-C* licenses do not entitle the holder to operate 'phone in the two restricted bands just noted but do permit him to engage in all other amateur operation. These two classes (*B* and *C*) are identical so far as privileges are concerned, their only difference being that the *Class B* is issued only when the license examination has been taken in the presence of the radio inspector, while the *Class C* is issued on the basis of a mail examination. The *Class B* is compulsory for all persons living within 125 miles airline of an examining point (exceptions: shut-ins, as noted below, and residents at CCC camps, military and naval personnel located at a military post or naval station, per Rule 404). Persons living more than 125 miles from an examining point may take the mail examination and obtain the *Class-C* license, which they may then renew indefinitely. It should be pointed out, however, that a *Class-C* license holder, if he violates regulations or otherwise incurs the official displeasure of the Federal Communications Commission, may be called upon to journey to the nearest examining point (even if it be considerably more than 125 miles away) to be examined personally, failing which his license will be revoked. Thus it par-

ticularly behooves every *Class-C* licensee to abide by the regulations in all his amateur operation.

Let us now treat the *Class B* and *C* licensing procedure in somewhat more detail.

Applying for Licenses

This section will be devoted to *Class B* and *Class C* applications; the *Class A* will be treated later in a separate section preceding the *Class A* examination questions.

We have just pointed out that anyone living within 125 miles of an examining point must, under the regulations, travel to that point and take the examination under the supervision of the inspector or one of his staff. Let us see what those points are.

There are 32 designated examining centers scattered throughout the United States and one in Hawaii. Of these, 21 are the regular inspection offices created by the Federal Communications Commission for the purpose of radio administration, and a list of them appears in the table at the rear of this booklet. Examinations are given at these 21 district offices once or twice a week. In addition, the following cities have also been designated as examination cities: Schenectady, Winston-Salem, Nashville, San Antonio, Oklahoma City, Des Moines, St. Louis, Pittsburgh, Cleveland, Cincinnati, Columbus (Ohio) and Washington, D. C. In all these cities but Washington examinations are given every three months on a date and at an address designated in advance. A card to the office of the inspector in whose district is located the particular city in which you are interested will bring information on the date and place. In Washington examinations are held every Thursday at the offices of the Federal Communications Commission.

Now, if you live within 125 miles *airline* of one of the above 33 examining points you should write or visit the inspector of the district in which you live, asking for an application blank for amateur station and operator license and the date when examinations will be held in the city at which you wish to appear. Fill out the application form and mail it *back to the inspector's office*, and then appear at the specified time for personal examination. First the inspector gives you your code test; if you are successful in passing this you will be given the written exam. After the examination is completed you can go home; the inspector sends all the papers to Washington and if you were satisfactory your combination license comes direct to your home a couple of weeks later. If, instead of receiving your licenses, you are notified that you failed, you have the privilege of taking the examination again (any number of times, if necessary) but must wait 90 days after the previous date of taking the test before taking it again. However, if you took your examination at one of the cities named in Rule 30-A, you can re-take it at that same city the next time tests are held even if, as sometimes happens, the elapsed period is not quite 90 days. See Rule 411.

If you live more than 125 miles *airline* from any of the 33 examining points, write the inspector of the district in which you live, asking for a *Class C* amateur operator and station application blank, examination, etc. He will send you an application form called Form 610, an instruction sheet, a return envelope addressed to the Federal Communications Commission at Washington, and a sealed envelope containing a set of examination questions. *Before doing anything else, read the instruction sheet carefully.*

Now, as part of the *Class-C* examination you have to have yourself examined in code speed by some licensed operator with whom you have made an arrangement to that effect. He must hold a license to operate radiotele*graph* stations, and the license must be of a grade higher than *Class C*. (Specifically, the classes acceptable for this code examiner are commercial extra first class; radiotelegraph operator first, second or third class; commercial operator first and second class; amateur *Class A* or amateur *Class B;* or a government radiotelegraph operator. See Rule 407.) You also have to provide yourself with a witness who will open the envelope of questions and certify that you wrote out the answers without assistance, but there is no reason why the code examiner and the examination witness may not be the same person. If you do not know a licensed operator in your vicinity, communicate with the nearest radio club or write your A.R.R.L. Section Communications Manager (directory in front of every issue of the League's magazine *QST*). You must know the name of your examiner-witness before filling out the application. There is, in fact, a specified sequence: first you fill out Form 610 (the application) which includes the data on the examiner and witness, and then you swear to it before a notary. Next you get your code examiner to give you your code test and to fill out and swear to a statement of your code speed, for which a space is provided on the application form. Then, and only then, are you ready for the written examination. If you do not pass the code test, you must return the examination envelope unopened, and wait 90 days before trying again. But if your code speed test was passed successfully, and the statement sworn to, your witness may *then* open the sealed examination envelope. He examines it and sees that it consists of five sheets of paper, each bearing a printed question at the top of each side, ten questions in all. He hands these to you. You proceed to the answering of the questions, using the space below each question. You must, unless disability prevents, write with ink, not typewriter or pencil, although you may draw any necessary diagrams with pencil. Your witness must remain constantly present, and at the conclusion sign and swear to a statement that he opened the envelope and that you wrote out the answers in his presence and without assistance

from any source. There is space for this also on the application form. Then you put both the application form and the examination sheets in the envelope provided, and mail them direct to the Federal Communications Commission. If you have passed, your license will come to you in about three weeks. If you have failed (you will be notified but will not be told on what questions you failed) don't be too discouraged—study some more for the examination and after 90 days try it again.

The application Form 610 is self-explanatory and needs no treatment here except to say that you should not be concerned over that item (Item 39) which requires you to waive claim to the use of any particular frequency or of the ether as against the regulatory power of the United States. This is a form requirement under the law, and agreement is required of all licensees, whether amateur or commercial.

Applicants for amateur licenses in Puerto Rico, Guam and Alaska, may apply for *Class-C* licenses through the offices of the inspectors at Miami, San Francisco and Seattle, respectively; in this case they must make arrangements for their code tests with such persons as qualify under Rule 407. Or, if desired, applicants in Puerto Rico and Guam may take the *Class-B* examination, in which case they must make arrangements with the Naval District Communications Officer at either San Juan, P. R., or Agana, Guam, who will undertake to give the examination to the applicant. *Class B* is not available in Alaska. Readers interested in *Class A* for these territories and possessions are referred to the introduction to the *Class-A* examination which appears farther on in this booklet.

Physical Disability

No physical infirmity, except total deafness, is a bar to issuance of amateur operator and station licenses provided the applicant can qualify. Invalids and shut-ins who live more than 125 miles from the nearest examining point will, of course, follow the usual mail procedure specified for the *Class-C* license. If, however, they live within the 125-mile limit but are genuinely incapable of traveling, they should write the Federal Communications Commission at Washington stating the circumstances. They will then be advised what procedure to follow. In all probability the distance requirement will be waived and the applicant permitted to apply for a *Class-C* license. Needless to say, the infirmity must be one of a permanent or semi-permanent nature; temporary sickness does not entitle one to exemption. See last paragraph of Rule 404.

Some applicants for license, whether it be *Class A, B* or *C*, are unable to comply with Rule 415 because of blindness or other disability. In such cases, the Commission has ordered that the examining officer or witness may permit the applicant to typewrite or dictate the code test and examination answers. When this practice is observed, the witness or examining officer must certify that the examination comprises solely the applicant's efforts or dictation, and that no outside assistance was rendered. The nature of the disability must also be stated and if the examination was dictated the name and address of the person who took the dictation must be noted.

Renewals

Provided you show a certain amount of operating activity for yourself and your station, both the operator and station licenses may be renewed indefinitely merely upon application. Since the two licenses have concurrent terms, they are renewed simultaneously.

The requirement for a specified amount of activity is essential, however, so you had better be thoroughly familiar with it. Turn back to the amateur regulations and read Rule 402. You will see that, as a condition for renewal of both station and operator licenses, it is required that you shall have worked at least three other amateur stations from *your station*, during the three-month period prior to the date of application for renewal. *Note this is the three-month period preceding the date of application*—not the three-month period preceding the date of expiration. Since you are required to submit application for renewal 60 days before the license expiration date, this means that sometime during that period between five months and two months before the date of expiration appearing on your license, you must be sure to get on the air and work at least three other amateur stations. These can be on any amateur band, however, and may be either 'phone or c.w. contacts.

Assuming you have the required activity, the procedure of renewal is simple. About three months before the date of expiration, send to your district radio inspector for the necessary blank for renewal of amateur station and operator licenses. When you get this, you will note it is the same form used for new applications and modifications; in your present case, of course, the heading is filled in as a "renewal." You should proceed fairly promptly to fill out and mail the application, since the regulations require that you submit a renewal application at least 60 days before the date of expiration of the licenses (on the other hand, do not send it in much more than 60 days in advance).

Filling out the blank is perfectly straightforward—being sure to include your evidence of activity—but you must fill out both the operator and station portions if you wish to renew both licenses. After filling out the application and executing the affidavit, you mail both the application *and* your expiring combination license direct to the Federal Communications Commission, Washington, D. C. Your new license will come to you from Washington in three or four weeks, and should reach you before the time is up on the turned-in ticket. You can con-

tinue to operate during this time that your license is away for renewal, subject to Rule 221(b); normally, the new license will be returned in plenty of time to insure uninterrupted operation.

If you fail to renew your licenses at the required time, or if you have been inactive and cannot comply with Rule 402, your licenses will not be renewed; not only will you have to take the code test and examination over again when applying for a new license, but you will be obliged to wait 90 days after the expiration date of your old ticket before you can get a new one. Moral: make sure you know the expiration date on your licenses and that you take the proper steps for renewal in plenty of time.

Modifications

The holder of a *Class-C* license is eligible for *Class B* (thereby eliminating the possibility of being called up for personal examination at an inconvenient time and distance) whenever and wherever he can arrange for personal appearance and examination before an inspector. If he has had a year's experience as a licensed amateur operator he is similarly eligible for *Class A*. The holder of a *Class-B* license is also eligible for *Class A* if he has had a year's experience. Personal appearance before the inspector is required of course. Passing any such higher grade license results in an endorsement "modifying" the operator license, without, however, changing its date of expiration. Rule 402, as to minimum activity, no longer applies in such cases. If you are interested in a higher class of license, communicate with the inspector of your district.

If you change your station's location by moving to another address in the same city, or to another part of the state, or into another state, you must apply for a "modification" to authorize the new address. The procedure for this is the same as an original application except that of course you do not have to pay any attention to those portions of the application form relating to the *operator* license. Write your district inspector for the usual amateur application form and fill out the "station" part as usual, except that it is now designated at the top as an application for modification. Nor do you have to cite three stations which have been worked from your station during the three months preceding the date of application for modification; Rule 402 does not apply for *modifications*, but only for renewals, as you will see by reading the rule in the rear of this pamphlet.

When you have filled out the form, mail it, together with your existing license, to the Federal Communications Commission, Washington, D. C., not to the inspector. Modifications of this type result in extensions of the license period; when you get your modified license back you will find it is really a new license running for a full three years.

Of course, if at the same time that you want to change the address of your station it is necessary for any reason for you to take an operator examination before the inspector, you would not mail any of the forms direct to the Commission. You would return them to the inspector and await his instructions when to appear for personal examination. Direct return to the Commission is in order only when no personal appearance is to be required.

When your licenses have to be mailed in for endorsement or modification, or any other change, you may continue to operate for a period of 60 days — unless your license expires before that time. This provision is equally applicable to operator and station licenses, since both must necessarily accompany any application for change. It is presumed that before the 60-day period has passed, your licenses will have been returned to you by the Commission.

Exemptions

Applicants who within the previous five years have held an operator license should carefully consult Commission Rules 405 and 406, printed in the amateur regulations towards the end of this booklet. If you now want Class B or Class C and within the past five years held an Amateur *Extra* First Class or certain specified grades of commercial radiotelegraph operator license, you are now exempt from the code test and from half of the examination. You escape that half relating to apparatus and adjustment and take only that half relating to laws, treaties and regulations affecting amateur licenses. Regardless of the class you now want, if within the past five years you held certain specified grades of commercial radiotele*phone* operator license or had an amateur license bearing endorsement for unlimited amateur radiotelephony, you are exempt from that portion of the examination relating to apparatus and adjustment. You have to demonstrate your code ability but your written examination is confined to laws, treaties and regulations affecting amateurs. This last exemption is particularly important to the Class A applicant of previous "unlimited" experience, since he escapes not only half of the basic examination but all of the extra examination relating to radiotelephony.

Passing the Operator Examination

And now to the examination itself. As we have previously mentioned, the Federal Communications Commission has prepared a list of several hundred questions from which ten will be selected at random for each individual examination. To facilitate selection, the Commission has established ten classes under the following general headings: Power Supply; Frequency Measurement; Transmitters — Theory; Transmitters —Practice; Radiotelephony; Treaty and Laws; F.C.C. Regulations, Part I; F.C.C. Regulations, Part II; F.C.C. Regulations, Part III; Penalties. Each amateur's examination will consist of one

question under each of these ten general topics. The questions and answers in this booklet have been carefully prepared as representative of the actual questions asked by the authorities, and if the applicant is familiar with them and feels he can answer them correctly, he need have no concern over the examination.

Needless to say, an amateur ought to be thoroughly familiar with the reasons for each answer; to this end he should study "*The Radio Amateur's Handbook*" for knowledge of basic radio and electrical theory, adjustment and operation of apparatus, etc., and should also study carefully the complete text of the amateur regulations as they appear in the rear of this booklet.

The person who can send and receive international code at the required "thirteen-per" and feels he can confidently answer any of the questions in this list need have no fear whatever of the government examination. And even if you should fail to pass, you can always take the examination again after 90 days have elapsed.

EXAMINATION FOR CLASSES B AND C

Power Supply

1. The amateur regulations require that the plate power supply on every tube of a transmitter operating on frequencies below 30,000 kc. must be filtered direct current. Explain why this practice minimizes frequency modulation and prevents the emission of broad signals.

(*Every applicant should be familiar with the reasons for adequately-filtered d.c. power supply.*) The frequency generated by the oscillator in a transmitter is more or less dependent on the plate voltage. Consequently, any variation in oscillator plate voltage will cause a change in frequency. If the plate voltage varies at the supply frequency or a multiple of the supply frequency, as it would in the case with an inadequately-filtered plate power supply, there would be frequency modulation of the oscillator's output. There would also be amplitude modulation of the oscillator and of the amplifier stages. The spurious radiations resulting from such frequency and amplitude modulation cause needless interference, making the wave broader than required for the type of transmission. The use of adequately-filtered plate power supply eliminates such frequency and amplitude modulation of the oscillator, as well as amplitude modulation of amplifier stages excited by the oscillator.

2. What is meant by the voltage regulation of a power supply?

Voltage regulation is a measure of the change in terminal voltage of a power supply between the limits of no-load and full-load current, often expressed as a percentage of the full-load voltage. When the voltage change is small the power supply is said to have good regulation; if the change is a large percentage of the full-load voltage the regulation is poor.

3. What effect will poor voltage regulation in a power supply have on a keyed oscillator?

The voltage will drop at the instant the key is closed, causing the frequency of the emitted signal to change. This is known as a keying "chirp."

4. Explain briefly the function of a filter in a power supply.

The purpose of a filter is to smooth out the audio-frequency voltage fluctuations present in the output of a rectified power supply, and to deliver to the load circuit a continuous and unvarying direct current.

5. What is the effect of an inadequate power-supply filter?

The output voltage of a power-supply system having an inadequate filter will not be sufficiently free from voltage fluctuations or ripple to prevent frequency or amplitude modulation when used on the plate of a vacuum-tube oscillator.

6. Why is it desirable to have separate transformers for plate-power and filament-heating purposes?

Separate transformers for these purposes are desirable because they tend to isolate the plate and filament power sources and thus prevent the rapid changes in plate-supply load, caused by keying, from affecting the voltage applied to the tube filaments. Changes in filament voltage with keying are likely to result in a change in oscillator frequency or "chirp."

7. Why is a filter necessary on a direct-current generator used as plate power supply?

A filter is required to smooth out the voltage fluctuations or ripple caused by commutation.

8. How may radio-frequency currents be kept out of the power supply?

Radio-frequency currents may be kept out of the power supply by the use of r.f. chokes in series with the leads connecting to the transmitter, and by the use of r.f. by-pass condensers connected across such leads.

9. What is the difference between a full-wave and half-wave rectifier?

A full-wave rectifier utilizes both alternations in a cycle of the a.c. input wave. A half-wave rectifier utilizes only one alternation and is idle during the other.

10. Name three methods of obtaining direct-current plate supply.

Several such methods are: Rectified and filtered output of an alternating-current source; a d.c. generator with a filter to eliminate commutator ripple, driven by a suitable motor or prime mover; a dynamotor with a suitable filter operating from a low-voltage d.c. source; a vibrator-transformer, operating from low-voltage d.c., whose output is rectified and filtered; storage or

dry batteries connected in series to give the required voltage.

11. How may plate voltage from a common source be applied to two or more circuits requiring different operating voltages?

By the use of series resistors to drop the voltage to the correct values at those circuits requiring a lower voltage than that of the source, or by the use of a voltage-dividing resistor suitably tapped for the same purpose.

12. How may it be determined whether a power supply is actually delivering direct current substantially free from ripple?

The output of the power supply may be connected to a loud-speaker or headset through a high-voltage condenser of about 2 microfarads. The magnitude of the ripple may be judged by the hum from the speaker or headset. An alternative method is to use the power supply on the plate of a stable oscillator and listen to the signal in a heterodyne monitor. If the plate supply is well filtered the signal will be free from modulation.

13. When more plate current is drawn through the filter choke than it was designed to handle, what is the effect on the inductance of the filter choke and on the filter action?

The inductance of the choke will decrease and the filtering will be impaired because the lower inductance permits more ripple voltage to pass through the filter.

14. With a.c. filament supply, why is a filament center-tap connection usually provided for the transmitting-tube plate and grid return circuits?

The filament center-tap connection is used to prevent modulation of the emitted signal at the a.c. filament-supply frequency. When the plate and grid return circuits are connected to the electrical center of the filament circuit, the voltages between the center-tap and the two ends of the filament oppose each other and thus prevent the grid and plate potentials from being affected by the filament supply.

15. Under what circumstances may an alternating-current generator, of say 500 cycles, be legally used to supply power for an amateur transmitter?

The generator may be used as a power supply on any amateur band if its output is rectified and filtered to produce continuous direct current. It may be used in the amateur band 56,000–60,000 kc. and from 110,000 kc. upwards without rectification or filtering.

16. Explain how a monitoring oscillator is used in checking the quality of the emitted signal.

The monitoring oscillator, which is sufficiently well shielded so that the signal picked up from the transmitter is of the same order of strength as those ordinarily heard on the receiver, is used as an autodyne detector to produce a beat note with the transmitter signal. By this means the character of the signal, as it sounds to distant receiving stations, can be determined.

17. What would be the effect on the emitted signal of attempting to key a transmitter by inserting the key between the power source and an adequate filter?

Because of the large energy-storage capacity of the filter, plate power would continue to be supplied during keying spaces so that the keying would be indistinct and unintelligible except at very low speeds. If the transmitter is a self-excited oscillator, there also would be a change in frequency with the slow rise and fall of plate voltage during keying, producing a chirpy signal.

Frequency Measurement

18. Explain how you would determine whether the frequency of your transmitter was within an amateur band.

The method requires the use of a monitoring oscillator or heterodyne frequency meter in conjunction with the receiver. The signal from the transmitter is picked up in the monitor, the tuning of which is then adjusted to zero beat with the transmitter frequency. The transmitter is then shut down, after which the receiver is adjusted to give zero beat with the monitoring oscillator. From knowledge of the tuning range of the receiver it is then known whether the transmitter frequency, which by this process has been referred to the receiver with fair exactness, is in an amateur band or not. If the receiver is sufficiently well shielded to permit obtaining a beat note with the transmitter frequency, the monitoring oscillator may be dispensed with; if this requires that the antenna be disconnected from the receiver, the receiver calibration must remain undisturbed with or without the antenna. Using these methods the transmitter frequency must be set well within the band to prevent the possibility of off-frequency transmissions since there is no exact measurement of the transmitter frequency.

If a calibrated heterodyne frequency meter is available the transmitter frequency may be measured as closely as the accuracy of the frequency meter permits. The process is the same as described above with the addition of a further step in which the frequency meter is adjusted to zero beat with either the monitor or receiver and the actual transmitter frequency checked by reference to the frequency-meter calibration curve. Alternatively, the monitoring oscillator may itself be calibrated in terms of frequency; or the heterodyne frequency meter, if of suitable construction, may be used directly for monitoring the transmitter.

19. How may a monitor be used to determine that your transmitter is adjusted to operate within an amateur band?

20. How would you measure your transmitter frequency with a heterodyne frequency meter?

The answer to these two questions will be

found in the answer to the first question under this section.

21. Why is it necessary to check frequently the "B" battery voltage of a calibrated frequency-monitoring oscillator?

Because a change in the "B" battery voltage will cause the frequency of the oscillator at a given setting of the tuning apparatus to change, and therefore render the calibration inaccurate.

22. What valuable uses has a monitoring oscillator in an amateur station?

A monitoring oscillator can be used to aid in setting the transmitter frequency within an amateur band; to give an aural check on the character of the transmitter signal and thus determine whether or not the plate-supply apparatus conforms with the regulations; to check the keying; and to maintain a continuous check on the transmitter during operation so that frequency changes or partial breakdowns of apparatus will be evident immediately.

23. What is a heterodyne frequency meter?

A heterodyne frequency meter is a vacuum-tube oscillator of high frequency stability whose variable tuning-element settings are calibrated in terms of frequency.

24. How would you adjust your transmitter to a particular desired frequency in an amateur band with the aid of a heterodyne frequency meter?

The heterodyne frequency meter should be adjusted to the desired frequency as shown by its calibration chart. The signal from the frequency meter is then tuned to zero beat on the receiver; then the monitoring oscillator is adjusted to zero beat with the frequency meter — in this step preferably with the receiver in a non-oscillating state for greater accuracy. The transmitter tuning is then adjusted to zero beat with the monitoring oscillator, the headphones having been shifted from the receiver to the monitor.

Depending upon the characteristics of the apparatus employed, this process may be varied somewhat. If the signal from the frequency meter can be heard directly in the monitor, the step involving the receiver may be omitted; if the frequency meter can itself be used as a monitor, both monitor and receiver can be omitted and the transmitter adjusted directly to zero beat with the frequency meter after the latter has been set at the desired frequency.

25. How would you calibrate a heterodyne frequency meter from received radio signals of known frequency?

With the receiver adjusted to the known signal but non-oscillating, the heterodyne frequency meter should be tuned to the same frequency, as evidenced by a beat note between the heterodyne oscillator and the incoming signal. When the frequency meter is adjusted to give zero beat with the signal it will be set to exactly the same frequency and the dial reading for that frequency should be recorded. Similar observations on a series of signals of different frequencies will result in a series of calibration points which can be used for the purpose of plotting a calibration curve.

26. Why must the calibration of a frequency meter be frequently verified?

Because a number of factors operate to change the oscillation frequency for a given dial setting and thus destroy the accuracy of the calibration. Among these are changes in filament and plate battery potentials with continued use, temperature effects, ageing of tube and circuit elements, and possible slight damage to circuit elements which changes their electrical constants.

27. If you had a frequency meter with a possible error of 0.5%, what is the lowest frequency in the 14,000-kc. amateur band to which you could safely set your amateur transmitter, and why?

14,070 kc. as shown by the calibration curve of the frequency meter, because the possible error is such that a setting between 14,000 and 14,070 kc. cannot be depended upon to be actually within the low-frequency limit of the 14,000-kc. band.

28. In operating your frequency meter, what is the effect upon frequency when the tuning condenser capacity is increased, and why?

The frequency decreases, because for a circuit containing a fixed inductance and a variable condenser, the frequency varies inversely as the square root of the capacity.

29. How would you determine whether your transmitter was radiating harmonics or spurious frequencies outside the amateur bands?

By listening with a receiver having a continuous frequency range, particularly on frequencies above the fundamental transmitter frequency, located at a sufficient distance from the transmitter to be out of the direct field of the transmitting apparatus.

30. If your frequency meter is accurate to two (2) kc. when set to 1750 kc., what is its error in kilocycles when set to 3500 kc.?

4 kc.

31. Why do most heterodyne frequency meters require "warming up" before they may be used for frequency measuring?

Because the heat radiated by the filament of the tube causes expansion of the tube electrodes and circuit elements and thus causes small changes in the circuit constants. As a result, the calibration will change to some extent. After the temperature becomes stable the expansion ceases, so the frequency meter should be allowed to "warm up" until the steady stage is reached.

32. Explain how a heterodyne frequency meter calibrated for the 1715–2000 kc. band may be used to adjust a transmitter for operation within the band 3500–4000 kc.

The answer to this question is the same as to the general question on the use of a heterodyne frequency meter in setting transmitter frequency,

except that in this case the heterodyne frequency meter is not set directly to the desired frequency but to exactly half that frequency. The receiver or monitor is tuned to the *second harmonic* of the frequency-meter oscillator; the second-harmonic signal has exactly twice the frequency given on the calibration chart for the dial setting used.

33. Why does an absorption-type frequency meter give different readings at different distances from the transmitter?

An absorption frequency meter functions by taking a small amount of energy from the transmitter and therefore must be rather closely coupled to the transmitter tuned circuit. When two circuits are closely coupled the resonance frequencies of both are changed to an extent which varies with the degree of coupling or distance between them; hence the resonance readings will be different at different distances.

Transmitters — Theory

34. Draw a simple schematic circuit diagram showing a self-excited oscillator using a single vacuum tube and briefly explain its operation.

A Hartley circuit is shown in Fig 1-A. The battery *A* heats the filament of the tube, causing it to emit electrons. Battery *B* puts the plate at a positive potential with respect to the filament and electrons are drawn to the plate. Any minute disturbance in the circuit will cause a change of potential between the grid and plate, resulting in an instantaneous change in the electron stream to the plate. Because of the high reactance of the choke coil, *RFC*, the change in plate current does not appear in the *B*-battery circuit but causes a potential to develop between the plate and filament through the condenser C_2 and the part of the coil L included between C_2 and the filament tap. Since this part of L is magnetically coupled to the part between the filament tap and the grid condenser, C_3, there is an induced potential between the grid and filament. This potential acts in such a way as to increase the change in plate current. The process continues, being reinforced by the amplifying properties of the tube, and when the power transferred to the grid circuit from the plate circuit is great enough to overcome the grid-circuit losses, a state of continuous oscillation is reached. The frequency of oscillation is determined by the constants of L and C_1 to a very close approximation. (The purpose of the grid condenser, C_3, and grid leak, R, is to keep the average potential of the grid negative with respect to the filament. When the instantaneous grid potential is positive, electrons are attracted to the grid and current flows in the grid-filament circuit; this current is unidirectional and cannot flow through C_3 but is made to flow through R, and the voltage drop resulting is utilized as grid bias. C_2 offers practically no impedance to the flow of r.f. currents. The direction of grid-current flow is such that the grid becomes negative with respect to the filament.)

35. Draw a simple schematic circuit diagram showing a self-excited oscillator using two vacuum tubes in push-pull arrangement, and briefly explain its operation.

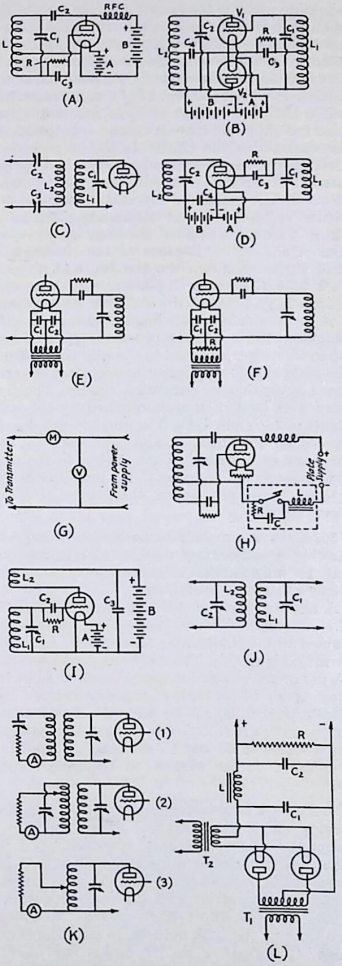

FIG. 1

A push-pull tuned-grid tuned-plate circuit is shown in Fig. 1-B. As in the preceding explanation, the filament battery heats the filaments of the tubes and causes electron emission; the "B" battery puts a positive potential on the tube plates and attracts electrons, causing plate current to flow. The circuits L_1C_1 and L_2C_2 are tuned approximately to the same frequency. Any slight disturbance in the grid circuit will cause the potentials of the grids to change with respect to the filament; since the grids are connected to opposite ends of the tuned circuit L_1C_1 a potential which causes the plate current of V_1 to increase will cause the plate current of V_2 to decrease. These changes in plate current cause a potential to develop across the circuit L_2C_2; the potentials developed by each tube separately add together across the circuit because of the push-pull connection. The change in instantaneous plate potential is larger than the originating potential in the grid circuit because of the amplifying properties of the tubes. Because of the electrostatic capacity existing between the grid and plate of each tube, the change in plate potential causes a change in grid potential which is in such a direction as to reinforce the original change in grid potential; the amplifying process is repeated and when the power returned to the grid circuit from the plate circuit is sufficient to overcome the grid losses a continuous oscillation ensues. The frequency of oscillation is determined by the constants of L_1C_1 and L_2C_2. The purpose and operation of the grid leak, R, and condenser, C_3, are the same as described in the answer to the preceding question. Condenser C_4 is a radio-frequency by-pass condenser, across the source of plate power supply.

36. Draw a simple schematic circuit diagram showing a satisfactory method of coupling the output of a transmitter to an antenna system, and briefly explain its operation.

A representative circuit is shown in Fig. 1-C. The antenna or feeder system is inductively coupled to the transmitter tank circuit, L_1C_1, by the coupling coil, L_2. The radio-frequency current flowing in L_1C_1 causes magnetic lines of force to be set up about L_1; these lines are intercepted by L_2, causing a voltage to be induced in L_2 which in turn causes current to flow in the antenna system. The condensers C_2 and C_3 are used to tune the antenna or feeder system to resonance with L_1C_1.

37. Draw a simple schematic circuit diagram showing series plate feed to a vacuum-tube oscillator and briefly explain its operation.

An oscillator circuit using series plate feed is shown in Fig. 1-D. In series feed the plate power is introduced in series with the radio-frequency circuit, and the direct plate current therefore flows through the tank inductance coil. The condenser, C_4, by-passes the r.f. across the power supply.

38. Draw a simple schematic circuit diagram showing shunt plate feed to a simple vacuum-tube oscillator and briefly explain its operation.

An oscillator circuit using shunt plate feed is shown in Fig. 1-A. In shunt feed the plate power is introduced in parallel to the radio-frequency circuit. To prevent short-circuiting the r.f. voltage developed across the tank circuit, a radio-frequency choke coil, *RFC*, must be connected between the power supply and the oscillator. The radio-frequency plate current of the tube flows to the tank circuit through the blocking condenser, C_2, which prevents short-circuiting the d.c. plate supply voltage through the tank coil, L, and the filament tap.

39. Draw a simple schematic circuit diagram showing grid-return connection to the center-tap of the filament-heating transformer and briefly explain its operation.

The circuit is shown in Fig. 1-E. Since the filament-heating power is supplied by alternating current, an alternating potential appears across the terminals of the filament transformer winding. If the grid return is connected to one side of the winding the alternating potential will cause the plate current of the tube to vary at the power-line supply frequency and will introduce modulation on the output of the oscillator. When the grid return is connected to the center of the winding, however, the instantaneous potential on one side of the center-tap is balanced by an opposite potential on the other side, hence there is no variation in grid potential and the filament-heating source introduces no modulation. The by-pass condensers, C_1 and C_2, provide a low-impedance path for r.f. currents flowing to the filament.

40. Draw a simple schematic circuit diagram showing grid-return connection to the electrical center of a filament circuit where the filament heating transformer has no center tap and briefly explain its operation.

The circuit is shown in Fig. 1-F. A resistor, R, having an ohmic value sufficient to limit the current flow through it to a reasonable value, and tapped at its midpoint, is connected across the filament circuit: the grid return is made to the midpoint of the resistor. The voltages across the two halves of the resistor are equal and opposite, hence the resistor performs the same function as the center-tapped transformer winding described in the answer to the preceding question. The by-pass condensers serve the same purpose.

41. Draw a simple schematic circuit diagram showing the employment of grid-leak bias in a simple vacuum-tube oscillator and briefly explain its operation.

The circuit is shown in Fig. 1-A. The operation is as follows: During the part of the radio-frequency cycle when the grid voltage is positive with respect to the filament, electrons are attracted to the grid, causing a flow of current.

This current, which is unidirectional, cannot flow in the external grid-filament circuit through the grid condenser, C_3, because the condenser will not pass direct current. Therefore the current must flow through the grid-leak resistor, R. As a result of the current flow, a d.c. voltage appears across the terminals of R, the value of which is equal to the product of the resistance of R in ohms by the grid current in amperes. The direction of current flow is such that the grid assumes a negative potential or bias with respect to the filament.

42. Draw a simple schematic circuit diagram showing a method for measuring plate power input to a vacuum-tube oscillator and briefly explain its operation.

The diagram is shown in Fig. 1-G. The voltmeter, V, reads the actual voltage at the plate-supply terminals of the oscillator while the milliammeter, M, reads the plate current in milliamperes. The plate power input is then the product of the plate voltage multiplied by the reading of M divided by 1000. The milliammeter must be placed as shown and not between the plate power supply and the voltmeter; in the latter case the milliammeter would read the current taken by the voltmeter as well as that taken by the tube and the calculated power would be greater than the true value.

43. Draw a simple schematic circuit diagram showing a method of preventing key-clicks when keying a simple vacuum-tube oscillator and briefly explain its operation.

The diagram is shown in Fig. 1-H. The iron-core choke coil, L, is placed in series with the key, which breaks the plate current to the oscillator tube. Because of its self-inductance, L opposes any sudden change of current in the circuit; hence when the key is closed the plate current does not reach its full value instantly but rises at a comparatively slow rate. As a result, the power output of the oscillator rises at a similar slow rate and shock excitation of the antenna, which causes key clicks, is avoided. Since L stores energy in magnetic lines of force, it also tends to keep the current flowing when the key is opened; this similarly causes the amplitude of oscillation to decrease slowly. Arcing would occur at the key contacts when the key is opened were it not for the condenser C, which is connected across the key to absorb the energy released by L. C retains its charge while the key is open, but discharges through the resistor R when the key is closed. If R were not in the circuit the discharge of C would again cause arcing at the key contacts at the instant of closing. When L, R and C are properly proportioned, key clicks will be prevented and sparking at the key contacts will be minimized.

44. Draw a simple schematic circuit diagram showing a filter for preventing keying clicks or thumps and briefly explain its operation.

The dotted enclosure in Fig. 1-H shows the filter alone. The operation is explained in the answer to the preceding question.

45. Draw a simple schematic circuit diagram showing electromagnetic feedback in a simple vacuum-tube oscillator and briefly explain its operation.

A circuit of this type is shown in Fig. 1-I. When the filament of the tube is lighted and plate voltage applied, any small disturbance in the grid circuit will cause a change in the potential of the grid with respect to the filament and thus cause the plate current to change. Since the plate current flows through L_2, which is inductively coupled to L_1, a voltage will be induced in L_1. If the two coils are correctly poled, the induced voltage will reinforce the original change in grid potential and the process will repeat itself, being amplified each time by the amplifying properties of the tube and building up to a continuous oscillation whose amplitude is limited by the tube and circuit characteristics and the operating voltages. The frequency of the oscillations is determined chiefly by the constants of L_1 and C_1. The grid condenser C_2 and leak R set the operating grid bias, and condenser C_3 by-passes the radio-frequency currents around the source of plate power.

46. Draw a simple schematic circuit diagram showing a tuned-grid tuned-plate vacuum-tube oscillator and briefly explain its operation.

The diagram is shown in Fig. 1-D. When the filament of the tube is lighted and the plate voltage applied, any small electrical disturbance in the grid circuit will cause the change in the potential of the grid with respect to the filament and thus cause the plate current to change. Since the plate current flows through L_2, the change in current will cause a voltage to be induced in L_2 which appears between the filament and plate of the tube, since by-pass condenser C_4 has negligible impedance for radio frequencies. Because of the amplifying action of the tube, the voltage so induced is larger than the original disturbance which caused it. Because of the electrostatic capacity existing between the grid and plate of the tube, the voltage existing between the plate and filament causes a further voltage to be induced on the grid which reinforces the change caused by the original disturbance. The process repeats itself and a continuous oscillation builds up, the amplitude of oscillation being limited by the tube and circuit constants and the operating voltages. Grid condenser C_3 and leak R set the operating grid bias. The frequency of oscillation is determined to a close approximation by the constants of the two circuits, L_1C_1 and L_2C_2, which are tuned approximately to the same frequency.

47. Draw a simple schematic circuit diagram showing electromagnetic coupling between two tuned circuits to transfer energy from one to the other and briefly explain its operation.

The circuit is shown in Fig. 1-J. When radio-frequency current flows in the circuit L_1C_1, electromagnetic lines of force are set up about L_1. These lines of force cut through the turns of L_2, causing a voltage to be induced in L_2 which in turn causes current to flow in the circuit L_2C_2. The transfer of energy will be maximum when the two circuits are tuned to the same frequency.

48. Draw a simple schematic circuit diagram showing a dummy or phantom (non-radiating) antenna, coupled to a transmitter output circuit for testing purposes, and briefly explain its operation.

The dummy antenna preferably should have a resistance equal to that of the normal antenna or feeder system at the point at which it is to be fed. Several methods of connecting a dummy antenna are shown in Fig. 1-K. That shown at (1) would be used when the dummy has comparatively low resistance (up to 50 ohms, approximately); that (2) is used when the dummy resistance is high (50 ohms or more); the arrangement at (3) also is suitable for use with dummy antennas of 50 ohms or more resistance. The purpose of the dummy antenna is to dissipate the power output of the transmitter without radiating it; relative power output can be measured if the resistance of the dummy is constant for the range of currents used, and absolute power output can be measured if the resistance of the dummy is known accurately. The dummy antenna is useful during tuning adjustments when it is necessary for the transmitter to deliver power but actual radiation of power is not essential.

49. Draw a simple schematic circuit diagram showing a satisfactory rectifier-filter power supply and briefly explain its operation.

The diagram is given in Fig. 1-L. Power from the supply line is stepped up in voltage by the transformer T_1, whose secondary winding is tapped at the center. The outside ends of the secondary winding are connected to the plates of the rectifier tubes, whose filaments are heated by means of the step-down transformer T_2. As the ends of the secondary winding of T_1 alternately become positive with respect to the center-tap, current flows through the respective rectifier tubes; since the tubes will pass current only in one direction the output of the rectifier is unidirectional but rapidly varying in voltage. The rectified voltage is applied to the filter, which consists of condensers C_1 and C_2 and the iron-core choke L. Because the choke and condensers possess the property of storing electrical energy, the pulsations in the rectified current are smoothed out, in much the same way as the flywheel on an engine smooths out the pulsations of the driver by mechanical storage of energy. If the values of L, C_1 and C_2 are properly chosen, the output of the rectifier-filter system will be continuous direct current, for all practical purposes. A satisfactory value for L would be 30 henrys, and for C_1 and C_2, 2 μfd. each, for a supply-line frequency of 60 cycles. The bleeder resistor R aids in stabilizing the load on the plate supply, and discharges the filter condensers when the power is turned off.

Transmitters — Practice

50. Explain why a high ratio of capacity to inductance in the tank circuit of a self-excited transmitter improves the frequency stability.

The relatively-large tank capacity tends to minimize those variations in frequency caused by changes in the inter-electrode capacities of the vacuum tube with heating. A high ratio of capacity to inductance in the tank circuit also minimizes the frequency variations caused by changes in plate voltage.

51. What precautions must be taken in the adjustment of a transmitter to prevent the emission of harmonics?

The antenna coupling should be loose and the plate power input to the last stage should not be excessive. Harmonic output also can be reduced by limiting the excitation and reducing the grid bias.

52. Explain how you would determine whether your transmitter was radiating harmonics.

This can be done by having a receiving station located at some distance from the transmitter listen on the frequencies that are harmonics of the transmitter frequency.

53. Explain how keying clicks may be eliminated, stating what auxiliary apparatus is required and how it is adjusted.

Key clicks may be eliminated by causing the amplitude of oscillation in the transmitter circuits to build up and decrease at a comparatively slow rate. This is accomplished by inserting inductance of suitable value in series with the keying circuit and by shunting the key with a condenser and resistor in series. The values of inductance, capacity and resistance should be adjusted to give the largest time constant consistent with clean keying.

54. What might happen to change the frequency of a transmitter since it was last operated, and how would you detect such a change before again engaging in radio communication?

The tuning adjustments may have been changed by persons not familiar with the apparatus, possibly through accident; differences in temperature may have caused a frequency change of small magnitude. Any such change can be detected by starting the transmitter with the antenna disconnected and noting whether the dial setting for the transmitter signal in the monitor or frequency meter has changed since the transmitter was last operated.

55. Suppose your self-excited transmitter erratically shifts frequency during operation. Name at least three possible causes.

A tube or other apparatus may be defective; a connection may be loose; antenna or feeder sys-

tem may be swinging, causing capacity changes which affect the oscillator frequency; antenna coupling may be too tight.

56. Describe a method of voltage feed to a Hertz antenna.

In one method, one end of the antenna is connected to a coil-condenser circuit tuned to the operating frequency; this circuit in turn is inductively coupled to the output tank circuit of the transmitter.

The second method, known as the Zeppelin system, utilizes a feeder consisting of two parallel wires, one wire of which is connected to the end of the antenna, the other wire being left free. The feeders, the length of which usually is some multiple of a quarter wavelength, terminate in tuning apparatus which is inductively coupled to the output tank circuit of the transmitter.

57. What are the advantages of an oscillator-amplifier type transmitter over a self-excited oscillator?

The efficiency of a properly-excited amplifier is greater than that of a self-excited oscillator because the amplifier's grid losses are supplied from a separate source; the frequency stability is better because the oscillator is isolated from the antenna system and therefore is little affected by changes in the antenna or feeder constants; changes in the amplifier plate-supply voltage have negligible effect on the frequency of the oscillator, so that plate-supply ripple does not result in frequency modulation or "wobbulation," and a key filter with a large time constant can be applied, if the amplifier tube only is keyed, without causing a keying chirp.

58. If you were operating on 3700 kc. and received notice that you were interfering with commercial service on 11,100 kc., what trouble in your transmitter would this indicate and what would you do about it?

This would indicate that the transmitter was radiating a strong third harmonic. Remedies for this condition would be to loosen the coupling to the antenna; to decrease the inductance-capacity ratio in the tank circuits; to lower the plate voltage on the oscillator or amplifier; to reduce excitation and bias on the amplifier or oscillator; and to insert a trap tuned to 11,100 kc. in the feeder system (or in one leg of the antenna in the case of a center-fed antenna without feeders). The trap should be inserted at a point which would represent a current anti-node on the antenna system at the frequency 11,100 kc.

59. Describe, giving dimensions, a suitable antenna system for operation in the amateur band in which you are chiefly interested.

The answer to this question will vary with the preferences of the individual taking the examination; complete information on antenna systems for all bands will be found in *The Radio Amateur's Handbook*. Typical answers would be as follows:

A suitable antenna system for the 1715-kc. band consists of a single horizontal wire 80 feet long, with a lead-in to the transmitter 40 feet long and a ground lead 10 feet long. The ground may consist of buried pipes or sheet metal, or may be a cold-water pipe connection. This antenna system would be tuned by a condenser in series with the antenna coupling coil.

A suitable antenna system for the 3500-kc. band would consist of a single horizontal wire 130 feet long with a two-wire feeder, one wire of which is connected to one end of the antenna, the other being left free at the antenna end. Each feeder wire should be 65 feet long and the two should be parallel, separated four to ten inches by suitable insulating spacers. The feeders would be tuned by two variable condensers connected in series with the coupling coil, one condenser in each feeder.

60. What are the advantages of keying an amplifier stage in an oscillator-amplifier transmitter?

Keying in the amplifier stage generally causes less change in frequency and minimizes keying chirps to a greater extent than is possible when the oscillator is keyed.

61. What method could be used to prevent your transmitter from feeding radio-frequency energy back into the power lines?

A power transformer having an electro-static shield between the primary and secondary windings could be used. Radio-frequency choke coils could be connected in series with the high-voltage and primary supply leads, and two radio-frequency by-pass condensers could be connected in series across the leads with the common connection of the two condensers grounded. The radiator of the antenna system could be located remote from the power lines and fed by a low-radiation transmission line kept well removed from the power wires.

62. What are the relative merits of a crystal-controlled transmitter and a self-excited transmitter?

The crystal-controlled transmitter has greater frequency stability than the self-excited transmitter, and can be depended upon to stay upon one frequency unless through misadjustment it is permitted to operate as a self-excited oscillator. The efficiency and power output also can be higher than is possible with the self-excited transmitter. Except for very low powers and relatively low-frequencies, however, more apparatus is required for the crystal-controlled transmitter, especially for operation on the higher-frequency amateur bands, where doubling amplifiers are usually necessary. The number of frequencies on which the crystal-controlled transmitter can work is limited by the frequencies of the crystals available, whereas the self-excited transmitter can be adjusted to any frequency in any amateur band.

63. If the frequency of your transmitter varies when the apparatus is jarred or vibrated, what should be done?

The mechanical construction of the transmitter should be improved to minimize the effects of jarring or vibration; and the transmitter should be insulated from the sources of such jarring or vibration by mounting it upon some vibration-absorbing material such as felt or sponge rubber.

64. Describe how you would connect a wave-trap to a broadcast receiver in order to eliminate interference from your transmitter.

The wave-trap which consists of a coil-condenser circuit which can be tuned to the frequency of the transmitter, should be connected in series with the antenna lead-in to the broadcast receiver, preferably as close as possible to the antenna binding-post on the receiver.

65. What effect has a swinging antenna upon the frequency and the power output of a transmitter (a) of the oscillator-amplifier type; (b) of the simple self-excited oscillator type?

(a) A swinging antenna will have practically no effect on the frequency of an oscillator-amplifier transmitter, but may cause the power output to vary. (b) A swinging antenna will vary both the frequency and power output of a self-excited transmitter.

Radiotelephony

66. What is frequency modulation and what undesirable effects does it produce or create?

Frequency modulation is a variation in the frequency of the carrier in accordance with the speech or other signal transmitted. Frequency modulation causes the signal to occupy a greater band of frequencies than those ordinarily required with pure amplitude modulation, thus creating unnecessary interference, and also results in the generation of spurious frequencies widely separated from the carrier which in turn can cause interference with other services.

67. Why do not amateur regulations permit radiotelephony by modulating a self-excited oscillator?

Because modulation of a self-excited oscillator results in frequency modulation as well as amplitude modulation, since the frequency of a self-excited oscillator is affected by changes in the plate and grid voltages.

68. What is overmodulation in radiotelephony and what undesirable effects does it produce?

Overmodulation is unsymmetrical amplitude modulation resulting in a change in the average amplitude of the carrier. It causes audio-frequency distortion of the signal and a broad interfering wave.

69. Why must a transmitter intended to be modulated for radiotelephony be so arranged that the modulation cannot affect the carrier frequency?

The transmitter must be so arranged that modulation cannot affect the carrier frequency, and thereby cause frequency modulation as well as amplitude modulation, in order to avoid generation of spurious radiations which would result in an unnecessarily broad interfering wave and distortion of the received signal.

70. In radiotelephony, what is a modulator?

A modulator is a device which varies the amplitude of the radio-frequency carrier in accordance with speech or other signal to be transmitted.

71. In radiotelephony, what is a speech amplifier?

A speech amplifier is an audio-frequency vacuum-tube amplifier of one or more stages which builds up the small signal from the microphone to a value suitable for proper excitation of the modulator tube.

72. What device is employed to convert sound waves into electrical variations for radiotelephony?

A microphone. The exact method of accomplishment depends upon the design. In general, there is a *diaphragm*, which vibrates in accordance with the sound waves striking it; the mechanical movement of the diaphragm causes a similar variation in either the current or voltage in an electrical circuit.

73. Why cannot the carrier frequency of a radiotelephone station be set as close to the edge of an amateur band as in the case of a radiotelegraph station?

Because in radiotelephone transmission radio frequencies additional to the carrier frequency are set up with modulation, causing the signal to occupy a band of frequencies rather than a single frequency. Allowance must be made for these side-band frequencies when the carrier is set near the edge of an amateur radiotelephone band.

74. What determines how close to the limits of the band the carrier frequency of a radiotelephone transmitter may be set, and why?

The highest modulation frequency transmitted determines this, because side-band frequencies are transmitted in addition to the carrier, and the carrier therefore must be set sufficiently well inside the band limit to be certain that no side-band frequency occupies territory outside the amateur band.

75. In radiotelephony, what is modulation?

Modulation is the process by which the amplitude of the carrier wave is varied in accordance with the speech or other signal to be transmitted.

76. What undesirable effects are created by excessive speech amplification in radiotelephony?

Undesirable effects created by excessive speech amplification are distortion of the speech or other signal and possibly overmodulation.

77. In radiotelephony, what is meant by the carrier?

The carrier wave is the unmodulated component of the signal wave.

78. In radiotelephony, what is a gain control?

A gain control is a device, usually a potentiometer, which controls the audio-frequency voltage input of a speech amplifier.

79. What causes frequency modulation in radiotelephony and how can it be prevented?

Likely causes of frequency modulation are variation in oscillator plate voltage when a common transmitter plate supply having poor regulation is used, reaction on the oscillator as the result of improper neutralization of an amplifier, modulated r.f. feedback to the oscillator, and vibration of the oscillator by an audio transformer or choke. To prevent frequency modulation, a stable oscillator such as the crystal-controlled type should be used, the oscillator plate-supply voltage should be made constant, a buffer amplifier should be used, r.f. amplifiers should be perfectly neutralized, and the oscillator circuit should be isolated from low-frequency equipment and should be shielded if necessary.

80. Describe a microphone and explain its operation.

In answer to this question, a description of any type of microphone can be given. A typical answer would be:

A carbon-type single-button microphone consists of a thin metal diaphragm, usually circular in shape and about two inches in diameter, at the center of which is mounted a small non-conducting receptacle loosely packed with fine polished grains of carbon or graphite. A small metal plate at the end of the receptacle farthest from the diaphragm serves as one electrode of the microphone, the diaphragm itself is the other electrode. In series with the microphone electrodes are connected the primary of an audio-frequency transformer and a battery or other source of low-voltage direct current, usually with a potentiometer or other means of varying the voltage applied to the circuit. The current through the microphone is adjusted according to the requirements of the microphone; usually a few milliamperes are sufficient. Sound waves striking the diaphragm cause it to vibrate; this alternately increases and decreases the pressure of the diaphragm on the carbon grains and causes the resistance of the microphone to vary in accordance with the sound waves. The variation in microphone resistance causes a similar variation in the current through the circuit, which in turn causes an audio-frequency voltage to be set up across the primary of the transformer. From the secondary of the transformer a stepped-up voltage is obtained which can be used to excite an audio-frequency (speech) amplifier.

81. In radiotelephony, what are side bands?

Side bands are bands of radio frequencies additional to the carrier frequency generated by the process of modulation. Numerically, they are equal to the carrier frequency plus and minus the modulation frequencies.

Treaty and Laws

82. Why do amateur station calls in the United States and possessions begin with the letter W or K?

Under international treaty each nation assigns calls to stations in its country only in accordance with an agreed-upon system which "parcels out" definite groups of calls from CAA to ZUZ to various nations (no calls are issued beginning with the letter Q, however, since combinations of letters under Q are utilized for international signalling purposes). Amateur calls in a given country must consist of a prefix of one or two letters, in accordance with this international alphabetical distribution, followed by a numeral and one or more additional letters. Under the international table, the United States is allocated all calls beginning with the letters K, N and W. Our government has specified that all amateur calls within the boundaries of the United States proper shall begin with W; U. S. amateur calls outside of continental United States begin with K.*

83. What are the international regulations relative to the maintenance of constant frequency and purity of signals?

The waves emitted by a station must be kept on the authorized frequency as exactly as the state of the art permits, and their radiation must be as free as practically possible from all emissions not essential to the type of communication carried on.

84. What is the Federal Communications Commission?

The Federal Communications Commission is the licensing and regulating authority on matters dealing with wire and radio communication in the United States. It is composed of seven commissioners appointed by the President. Among its duties are to classify radio stations; prescribe the nature of service to be rendered; assign bands of frequencies or wave lengths; determine the power, operating hours and location of each class of station. It is the Federal Communications Commission which issues licenses.

85. What class of radio communications holds precedence over all others?

Distress calls and distress communications hold precedence over all other classes of radio communications.

86. What is the law regarding the amount of power to be used to communicate over a given distance?

The minimum power necessary to carry on the desired communication must be used at all times,

* Some amateur stations licensed to members of the U. S. Naval Reserve are authorized to use the prefix "N." See Rule 384a.

except in communication relating to vessels in distress.

87. What is the law regarding the transmission of false or fraudulent communications?

No one shall knowingly transmit any false or fraudulent signal of distress or communication relating thereto.

88. What is the law regarding willful or malicious interference?

Willfully or maliciously interfering with any other radio communications or signals is prohibited.

89. What is the law regarding the transmission of obscene or profane language?

No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

90. Name three Q signals from the International List of Abbreviations and give their meanings.

The applicant should familiarize himself with the more commonly used Q signals. Some typical examples are:

QRA? What is the name of your station?
QRA The name of my station is . . . .
QRK? Are you receiving me well? Are my signals good?
QRK I receive you well. Your signals are good.
QRM? Are you being interfered with?
QRM I am being interfered with.]
QRT? Shall I stop sending?
QRT Stop sending.

91. What are the meanings of SOS, QRT, QRM, MAYDAY, CQ?

SOS is the international distress signal for all radiotelegraph stations. QRT means "Stop sending." QRM means "I am being interfered with." MAYDAY (from the French pronunciation of *M'aidez*, meaning "Help me") is the international distress signal for radio*telephone* use. CQ is the general call to all stations and has two uses. It may be used as a signal of inquiry when desiring to communicate with any station within range in which case the call is terminated with the letter K. It may also be used as a preface to broadcasts to which no reply is expected, in which case the terminating letter K is omitted.

92. What is the law regarding the secrecy of radio communications?

See Section 605 of the Communications Act of 1934, in the extracts at the end of this booklet. Briefly, the contents or meaning of an addressed message must not be divulged to other than the addressee or his agent, except to an authorized communication channel or upon the demand of a competent court; nor may a message be intercepted and divulged even to the addressee without the authority of the sender; nor may any person use the information in an addressed message for his own benefit.

93. What radio communications are not subject to the secrecy provisions of the Communications Act of 1934?

The secrecy provisions do not apply to information which has been broadcast for public use or relating to ships in distress.

94. Why does the Communications Act of 1934 require a station license even though the transmitting range of the station is extremely limited?

The regulation of all interstate communication is a function of the federal government, and station licenses are required not only for transmitters whose signals extend beyond the boundaries of the state in which they originated (as they are likely to do in even very low-power transmitters on the high frequencies) but also for transmitters which are capable of interfering with reception of out-of-state signals on nearby receivers. The effect of the law, therefore, is to require a station license for every transmitting installation, regardless of power.

95. What does the Communications Act of 1934 provide in regard to the control of radio stations during a national emergency?

See Section 606 (c) of the Communications Act. Briefly, during a national emergency of any sort, the President is empowered to suspend or amend the radio rules and regulations for any and all classes of stations, and may, if necessary, order all stations closed and apparatus dismantled, or may authorize the use of all such apparatus by the government in which latter case the owner will receive just compensation for his station.

96. What are the international regulations concerning superfluous signals?

The exchange of superfluous signals or correspondence — meaning any signals not necessary in carrying on the radio communication — is forbidden at all stations.

97. What type of communications may be exchanged between amateur stations of different countries?

Amateurs in different countries must confine their exchange to communications having to do with their experiments and/or to remarks of such a nature that they would not be sufficiently important to send by public telegraph or cable service. Unless special arrangements have been made between the governments of the two countries concerned, third-party messages (that is, messages addressed to or from some person other than either of the amateurs concerned in the contact) may not be handled.

F. C. C. Regulations, Part 1

98. State the frequency limits of at least four of the bands of frequencies assigned to radio amateurs.

Every amateur should be familiar with the frequency limits of *all* the amateur bands, which are as follows:

1,715 kc. to 2,000 kc.
3,500 kc. to 4,000 kc.
7,000 kc. to 7,300 kc.
14,000 kc. to 14,400 kc.
28,000 kc. to 30,000 kc.
56,000 kc. to 60,000 kc.
400,000 kc. to 401,000 kc.*

99. In what bands of frequencies may every amateur engage in radiotelephony?

100. What bands of frequencies are available for radiotelephony by specially qualified amateurs only?

The following bands are open to telephony by any amateur:

1,800 kc. to 2,000 kc.
28,000 kc. to 29,000 kc.
56,000 kc. to 60,000 kc.
400,000 kc. to 401,000 kc.*

Holders of Class-A licenses are entitled to use the following additional bands for radiotelephony:

3,900 kc. to 4,000 kc.
14,150 kc. to 14,250 kc.

101. In what bands of frequencies may tone-modulated radiotelegraphy (type A-2 emission) be employed?

Only in the following bands:

28,000 kc. to 30,000 kc.
56,000 kc. to 60,000 kc.
400,000 kc. to 401,000 kc.*

102. In what bands of frequencies is filtered direct-current plate supply required?

Filtered direct-current plate supply is required in the following bands:

1,715 kc. to 2,000 kc.
3,500 kc. to 4,000 kc.
7,000 kc. to 7,300 kc.
14,000 kc. to 14,400 kc.
28,000 kc. to 30,000 kc.

103. What types of emission may be employed in the amateur band 56,000 kc. to 60,000 kc.?

Either Type A-1 (pure d.c. telegraphy); Type A-2 (tone-modulated telegraphy); Type A-3 (telephony); and Type A-4 (television, facsimile or picture transmission).

104. Which of the five following frequencies have their second harmonic in the amateur band which begins at 7000 kc.: 3495, 3525, 3600, 3645, 3655?

Harmonics are multiples of a stated frequency: i.e., a second harmonic of a frequency is found by multiplying it by two, a third harmonic by multiplying by three, etc. Multiplying all of the above frequencies by two, therefore, since the question is regarding their second harmonic, we find that the second harmonics are, respectively, 6990, 7050, 7200, 7290, 7310. Knowing that the amateur band which begins at 7000 kc. runs from there to 7300 kc., we see that all except the first and the last of the five frequencies listed have their second harmonic in the amateur band which begins at 7000 kc.

105. What type or types of emission may be employed in the amateur band 7000 to 7300 kc.?

Only Type A-1 — pure filtered d.c. telegraphy.

106. In what portion of the amateur band 28,000 to 30,000 kc. may radiotelephony be used?

Only in the portion 28,000 to 29,000 kc.

107. Why may not a 3700-kc. crystal be used in a transmitter which doubles frequency for operation in the amateur band beginning at 7000 kc.?

If we doubled the frequency of the crystal in the transmitter, it would give us a doubled frequency of 7400 kc. — which is outside the band and, therefore, not permissible.

108. (a) What types of emission may be employed in the amateur band 3500 to 3900 kc.? (b) In the band 3900 to 4000 kc.?

(a) Only type A-1 — pure d.c. telegraphy. (b) Either type A-1, or type A-3 — radiotelephony — but it should be remembered that, in accordance with Rule 377 of the Rules and Regulations of the Federal Communications Commission, only holders of Class-A amateur licenses may use this band for telephony, type A-3.

109. (a) What portion of the amateur frequency band 1715 to 2000 kc. is open to radiotelegraphy? (b) What portion to radiotelephony?

(a) All of it. (b) 1800 to 2000 kc.

110. (a) May radiotelephony be engaged in the amateur frequency band 56,000 to 60,000 kc.? (b) In the band 28,000 to 30,000 kc.?

(a) Yes. (b) Only in that portion of it from 28,000 to 29,000 kc.

111. Explain whether the frequency band 14,150 to 14,250 kc. is available for unrestricted amateur radiotelephony.

Be careful with this question, since confusion between "unrestricted" and "unlimited" may cause you to give the wrong reply. The band is not available for unrestricted amateur radiotelephony; instead, it is restricted to those possessing the special (unlimited) 'phone privileges granted under the Class-A operator license.

112. In what frequency bands may an amateur operate a portable-mobile station?

Only in the bands 28,000–30,000 kc., 56,000–60,000 kc., 400,000–401,000 kc. and 110,000 kc. upward; other than this, portable-mobile station operation under an amateur license is not permitted.

113. Under what conditions may radiotelephony be employed in the frequency bands 3900 to 4000 kc. and 14,150 to 14,250 kc.?

These bands may be used for radiotelephony only when the operator holds an amateur oper-

*Amateurs may also operate any type of transmitter on any frequency above 110,000 kc., as may the experimental services.

ator's license of Class-A grade; Class-B and Class-C license holders are not permitted to use 'phone in these bands.

F.C.C. Regulations, Part II

114. What is the maximum power permitted amateur stations?

A maximum input power of one kilowatt is permitted. In a transmitter employing only a self-excited oscillator, this means a maximum of one kilowatt to the plate circuit of the oscillator tube or tubes; in an oscillator-amplifier transmitter it means a maximum of one kilowatt to the plate circuit of the final amplifier stage.

115. Under what circumstances may an amateur station be required to observe a silent period?

Quiet hours, from 8:00 p.m. to 10:30 p.m., local time, and on Sundays during an additional period from 10:30 a.m. until 1 p.m., local time, may be imposed upon amateur stations which interfere generally with broadcast reception on receivers of modern design. Quiet hours need be observed, however, only upon such frequency or frequencies as cause interference; e.g., if operation in the 3500-kc. band causes interference, but 7000-kc. band operation does not, quiet hours must be observed on the former band but need not be on the latter.

116. What restriction in operation is put upon amateur stations which interfere generally with broadcast reception on receivers of modern design?

See preceding question and answer.

117. May amateur stations broadcast entertainment?

No, amateur stations may not be used for broadcasting any form of entertainment, nor for the simultaneous retransmission by automatic means of programs or signals emanating from any class of station other than amateur.

118. Under what restrictions may amateur radiotelephone stations transmit music?

In connection with the development of experimental radiotelephone apparatus, amateur stations may transmit music for tests of short duration. Broadcasting or transmitting for entertainment purposes is not permitted.

119. What is a radio amateur?

A radio amateur is a duly-authorized person interested in radio technique from a strictly personal point of view and without pecuniary interest.

120. What notice must be given prior to the operation of a portable station?

The Inspector-in-Charge of the district in which the station is to be operated as a portable must be advised prior to the actual portable operation, the notice to give the station call, the name of the licensee, the dates of proposed operation and the approximate locations (as by city, town or county) where operation will take place. No notice may be filed to cover operation for a period of more than 30 days at a time; when operation beyond that time is desired, further notice must be filed. This applies only to frequencies below 28,000 kc. Above 28,000 kc. it is not necessary to give notice to the inspector before engaging in portable (or portable-mobile) operation.

121. (a) Is the keeping of a station log compulsory? (b) Is the licensee obliged to make it available to authorized government representatives upon demand?

Yes, to both questions.

122. How often must an amateur station sign its call?

An operator of an amateur station shall transmit its assigned call at least once during each fifteen minutes of operation and at the end of each transmission.

123. How long before expiration of an amateur license must application for renewal be filed and with whom?

Application for renewal of license must be filed at least 60 days prior to the expiration of the license to be renewed; it shall be filed with the Federal Communications Commission, Washington, D. C.

124. Explain the difference between a portable and a mobile station.

A portable station is one so constructed that it may conveniently be moved about from place to place and is so moved but is not operated while in motion; a mobile station is one capable of being moved and which is ordinarily operated while in motion.

125. (a) Who may manipulate the key of an amateur radiotelegraph station? (b) Who may transmit by voice over an amateur radiotelephone station, and under what circumstances?

(a) Only a licensed amateur operator may manipulate the key of an amateur radiotelegraph station. (b) An unlicensed person may speak over an amateur 'phone station, but only if a regularly licensed amateur operator is present and in charge of the operation of the transmitter.

126. Under what circumstances may an amateur station communicate with other than amateur stations?

In emergencies or for testing purposes they may also be used for communication with commercial or government radio stations. Also, they may communicate with any mobile station licensed by the Commission to communicate with amateur stations, and they may communicate, too, with stations of expeditions which may be authorized to communicate with amateurs.

127. What restriction exists against accepting pay for services performed by an amateur station?

Amateur stations are strictly prohibited against sending or receiving message for hire, or from otherwise accepting any compensation or pay for

services they perform, whether this be directly or indirectly done.

128. (a) May other than citizens of the United States obtain an amateur station license? (b) May other than citizens of the United States obtain an amateur operator license? (c) What restriction is there as to the nationality of the person who controls the premises upon which an amateur station is located?

(a) No. (b) No. (c) The person controlling the premises upon which an amateur station is located must be a citizen; a station license will not be issued if an alien controls the premises.

129. Why do the amateur regulations require the transmitter to be loosely coupled to the radiating system?

In order to minimize keying impacts and harmonics and to maintain frequency stability.

F.C.C. Regulations, Part III

130. Is it permissible to operate an amateur station by some form of automatic transmitter without a licensed operator present? Explain.

No; an automatic transmitter may be used, but a licensed operator must be present at all times when the station is in operation.

131. What are the hours during which an amateur station must not be operated on interfering frequencies when it has been directed to observe quiet hours?

Quiet hours are from 8:00 p.m. to 10:30 p.m., local time, and, in addition, from 10:30 a.m. until 1 p.m. on Sundays.

132. What identifying signal, in addition to its call, must be transmitted by a portable or portable-mobile amateur radiotelegraph station?

Immediately after signing the normal station call the portable transmitter must send the "break" sign (BT) followed by the number of the amateur call area in which it is operating.

133. What identifying announcement, in addition to its call, must be transmitted by a portable or portable-mobile amateur radiotelephone station?

In a portable 'phone station, the call sign of the station shall be followed by an announcement of the amateur call area in which it is operating.

134. What data must be recorded in the operating log of an amateur station?

The log must include the date and time of all transmissions; the name of the person manipulating the transmitting key of a radiotelegraph transmitter, or the name of the person operating a transmitter of any other type, with statement as to the nature of the transmission; station called; input power to the oscillator, or to the final amplifier stage where an oscillator-amplifier transmitter is employed; the frequency band used; in the case of a portable or portable-mobile station, the location at each transmission; and the message traffic handled, if any.

135. How long may a portable amateur station remain in operation at any one location without giving further notice to the inspector in charge of that district?

Thirty days.

136. Is it permissible for you to permit the operation of your amateur radiotelegraph station by a person holding only a professional radiotelegraph operator's license?

No; only the holders of amateur operator licenses may operate amateur stations.

137. For what purposes may the call signal CQ be used?

It may be used as a signal of inquiry when desiring to communicate with any station within range, in which case the call is terminated with the letter K. It may also be used as a preface to broadcasts to which no reply is expected, in which case the terminating letter K is omitted.

138. If you speak the language of a foreign country and were in radio communication with an amateur station in that country, would it be permissible for you to employ that foreign language for the communication?

Yes; that is still "plain language."

139. (a) What signal denotes the end of a message? (b) What signal denotes the end of communication between two stations? (c) What does the letter K at the end of a call mean?

(a) The signal AR is used to denote the end of a message. (b) The signal SK denotes the end of communication between two stations. (c) The use of K at the end of a call is an invitation for the other station to go ahead, and indicates to him that you have finished your transmission for the moment and will start listening for him.

140. Amateur stations are limited to a specified maximum input power. Where is this power measured?

In a transmitter employing only a self-excited oscillator, this power is measured in the plate circuit of the oscillator tube or tubes; in an oscillator-amplifier transmitter it is measured in the plate circuit of the final amplifier stage.

141. As an amateur operator, what would you do if you heard a ship transmitting a distress signal?

All transmission capable of interfering with the signals of the distressed ship, or of stations communicating with it, must be stopped immediately. The operator should continue to listen until it is apparent that the ship is receiving assistance. If no one seems to answer the ship, full particulars should immediately be transmitted by land line to the nearest government or commercial station. Everything possible should be done to bring assistance to the distressed ship without risking radio interference to those in a position to aid.

142. Under what circumstances may an amateur station be operated on a mobile unit?

An amateur station may be operated on a

portable-mobile basis if its transmissions are confined to operation in the bands 28,000–30,000 kc., 56,000–60,000 kc. and above 110,000 kc. See Question 120, also.

143. What is an amateur portable-mobile station?

A portable-mobile station is a station so constructed that it may conveniently be moved from one mobile unit to another for communication, and that is ordinarily used while the mobile unit on which it is located is in motion.

144. If you wish to maintain a portable amateur station and a "fixed" amateur station at the same time, and therefore require a second license: (a) will photostat copies of the station license serve for additional stations? (b) is a photostat copy of the operator license acceptable for the operation of any station?

(a) Yes. (b) No; the operator should always have the original operator license posted or in his possession wherever operating, whether at his own station or elsewhere.

145. (a) What is meant by type A-1 emission? (b) Type A-2 emission? (c) Type A-3 emission?

(a) Type A-1 emission is "pure d.c." radiotelegraphy. (b) Type A-2 emission is tone-modulated radiotelegraphy. (c) Type A-3 emission is radiotelephony.

Penalties

Before going on to questions regarding penalties, the reader should have a clear understanding of the difference between violations of the basic Communications Act of 1934, and of violations of the rules and regulations set up by the Federal Communications Commission under that act.

In the rear of this booklet are reproduced pertinent sections of the Communications Act of 1934. It goes without saying that the applicant for a license should read these extracts and familiarize himself with them. As will be seen, the basic Communications Act created the Federal Communications Commission, gave it authority, laid down the rules under which it may operate, etc. Then, after the Commission was created, it set up a list of operating rules and regulations for the various classes of license, both operator and station. These operating rules and regulations are set up under the basic Communications Act of 1934 but are not a part of it.

Such things as operation without a license, false statements in connection with applications, the prohibition against the transmission of profane or obscene language, or false distress signals, or the violation of the secrecy of all radiocommunications are part of the Communications Act of 1934. On the other hand, such matters as the use of pure d.c. in certain specified amateur bands, or the observance of quiet hours, etc., are part of the rules and regulations of the Federal Communications Commission.

Any person, whether or not he is a licensed operator, is liable to penalties for violation of either the Communications Act or the Rules and Regulations of the Commission; in addition, if the violator is a licensed operator, he is liable to suspension of his license.

Violations of the provisions of the basic Communications Act constitute the bigger offense and are punishable by fines of not more than $10,000 or imprisonment for a term of not more than two years, or both, for each violation. Violations of the rules and regulations of the Commission are punishable by a fine of not more than $500 for each and every day during which such offense occurs. In addition, any licensed operator who violates either the Communications Act or a regulation, or the provision of any international treaty binding upon the United States, may have his operator license suspended for a period up to two years. For instance, a licensed operator who violated the oath of secrecy (secrecy of radiocommunications being provided in the basic Communications Act of 1934) might be fined up to $10,000 or imprisoned for a period up to two years, or both, and also have his operator license suspended for a period up to two years.

So much for operator considerations. A station license cannot be suspended but it can be revoked by the Commission by due process if it is established that the applicant for station license made false statements in connection with the application, or for failure to operate the station as set forth in the regulations, or for failure to abide by such acts or treaties as may apply.

146. What penalty may be imposed for a violation of the provisions of the Communications Act of 1934?

A fine of not to exceed $10,000, or imprisonment not to exceed two years, or both, for each offense; in addition, a licensed operator convicted of violation of the Communications Act is liable to suspension of his license for a period not to exceed two years. The station license, if any, may also be revoked.

147. What penalty may be imposed for a violation of any regulation of the Federal Communications Commission made under the Communications Act of 1934?

A fine not to exceed $500, for each day of such offense; in addition, if the person convicted is a licensed operator, he is liable to suspension of license for a period not to exceed two years. The station license, if any, may also be revoked.

148. What penalty may be imposed upon the licensee of a licensed amateur station if he permits the operation of his station by an unauthorized person?

This is a violation of the basic Communications Act of 1934 and is subject to the penalties set forth in the answer to Question 146. The station license is liable to revocation, also.

149. What penalty may be imposed for operat-

ing a licensed amateur station without an amateur operator license?

This is a violation of the basic Act; the unlicensed person so convicted is subject to the fines and imprisonment stated. (The station licensee, if another person, is also subject to penalties as discussed under Question 148.)

150. What penalty may be imposed for transmitting profane or obscene language?

A violation of the basic Communication Act, and punishable by the penalties outlined for such violation. If the person convicted is a licensed operator, he is liable to suspension of his license, as outlined; if he is the holder of a station license, that license is liable to revocation.

151. What penalty may be imposed for divulging the contents of radiocommunications to unauthorized persons?

Since this is a violation of the Communications Act the penalties set down for such violation apply. (But be sure to give them.)

152. What penalty may be imposed for transmitting a false or fraudulent distress call?

A violation of the Communications Act; give the penalties which apply for such violation, as outlined previously.

153. What penalty may be imposed for failing to keep a log of station operation?

This is a violation of the regulations, and is subject to fine of not to exceed $500 for each day of such offense, plus suspension of operator license.

154. What penalty may be imposed for maliciously interfering with the transmissions of other stations?

In the case of communications relating to vessels in distress, up to $10,000 and 2 years; see 146. In the case of other communications, suspension of operator license up to 2 years.

155. What penalty may be imposed upon a licensed amateur operator who signs a false station call?

A violation punishable by the penalties set forth for violations of the basic Act; again see 146.

156. What penalty may be imposed upon an amateur licensee for operating on a frequency outside an authorized amateur band?

Section 301 of the Communications Act provides against the operation of a radio station "except under *and in accordance with* . . . a license in that behalf granted under the provisions of this Act. Section 303(c) provides for the assigning of frequencies for each individual station. Therefore operation outside the frequencies assigned is a violation of the Act itself and invites the provided penalties; see 146.

157. What penalty may be imposed upon an amateur licensee for operating his station with inadequately filtered power supply?

158. What penalty may be imposed upon an amateur licensee who wilfully fails to observe quiet hours when required to maintain them?

159. What penalty may be imposed upon an amateur licensee for operating a radiotelephone station on the band 3900–4000 kilocycles without holding an operator's license which authorizes unlimited 'phone operation?

160. What penalty may be imposed upon an amateur licensee who operates a portable station (on frequencies below 28,000 kc.) without previously having notified the Inspector of the time and place of the contemplated operation?

161. What penalty may be imposed upon an amateur licensee who accepts material compensation for any services rendered by his station?

All these are violations of the rules and regulations set up by the Federal Communications Commission, and are punishable by fine not to exceed $500 for each day of such offense. The licensee, of course, is also liable to suspension of his operator license for a period up to two years and may, in addition, have his station license revoked.

QUESTIONS FOR THE CLASS-A EXAMINATION

The subjects so far treated in this booklet are all that one has to know to pass the examination for the ordinary amateur license of *Class B* or *C*. Such a license permits c.w. telegraph operation in every amateur band and 'phone operation in the bands 1800–2000 kc., 28,000–29,000 kc., 56,000–60,000 kc. and all frequencies above 110,000 kc. To engage in 'phone transmission in the more desirable bands, 3900–4000 kc. and 14,150–14,250 kc., additional authorization is needed, which may be had only by passing the *Class-A* examination. To be eligible, the applicant must have had at least one year's experience as a licensed amateur operator. If he is thus eligible but at the moment does not possess a *Class-B* license, the *Class-A* examination consists of 10 questions forming a *Class-B* examination plus 10 additional advanced questions relating exclusively to amateur radiotelephony. But if he is thus eligible and already possesses a *Class-B* license, the examination consists only of the 10 additional questions on radiotelephony.* As in the case of the *Class-B* and *Class-C* test, the telephony examination consists of one question under each of ten headings. The following questions are representative and familiarity with them should constitute adequate preparation, when combined with study of theory in *The Radio Amateur's Handbook*, particularly Chapter VIII, "Radiotelephony".

Applicants for *Class-A* who reside within continental United States or the territory of Hawaii must appear in person before an examining officer at one of the examining points named in Rule 30. Applicants in Alaska, Puerto Rico and Guam may also take the examination but under somewhat different circumstances. In Alaska, arrangements may be made with any Army official to secure the sealed envelopes for this examination from the inspector at Seattle and administer

*The Commission has ruled that when an amateur holding a Class-C license appears before an inspector to take the Class-A examination, he must take the Class-B examination as well, including the code test.

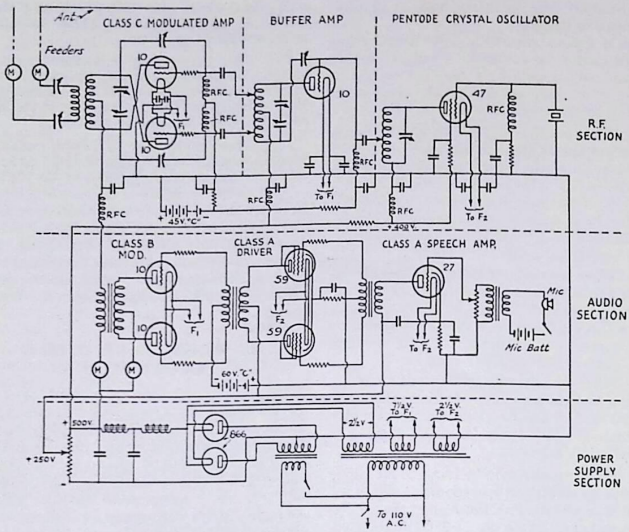

FIG. 2—DIAGRAM OF A COMPLETE MODERN AMATEUR RADIOTELEPHONE TRANSMITTER USING CRYSTAL CONTROL AND CLASS-B MODULATION

the test. In Puerto Rico and Guam, the Naval District Communications Officers at San Juan and Agana, respectively, are authorized to give the *Class-A* examination.

Diagram

162. Draw the schematic circuit diagram of a modern amateur radiotelephone transmitter, complete with plate and filament power supplies and antenna system, showing a crystal-controlled oscillator, a buffer amplifier, a modulated amplifier, a modulator, a speech amplifier, and a speech input circuit including microphone.

(*Every applicant should be capable of drawing a complete schematic diagram of the type indicated by our question.*) A typical diagram is shown in Fig. 2. Legend and constants are not required now.

Phone Theory

163. What is the necessary ratio of modulator audio power output to Class-C amplifier plate input for 100% modulation?

For 100% modulation by a single pure-tone (sinusoidal) signal, the modulator average power output must be 50% of the Class-C amplifier unmodulated plate power input. For speech, however, the modulator average power output for 100% modulation is approximately 25% of the Class-C amplifier unmodulated plate input.

164. Define percentage of modulation, showing a simple drawing of a wave modulated 100%.

Percentage modulation is defined as 100 times the maximum increase or decrease in amplitude of the modulated wave, divided by the unmodulated amplitude. In other words, it is 100 times the maximum departure (positive or negative) of the envelope of the modulated wave from its unmodulated value, divided by its unmodulated value. If the modulation is undistorted and therefore symmetrical, the positive ("upward") and negative ("downward") percentage values are the same; but if the modulation is distorted, the positive and negative values may be different. A drawing showing a wave modulated 100% by a single undistorted tone is given in Fig. 3.

165. What radio frequencies additional to the carrier frequency are produced by the process of amplitude modulation?

Radio frequencies having numerical values equal to the carrier frequency plus and minus the modulation frequencies are produced by the process of amplitude modulation. These frequencies are symmetrically distributed on both

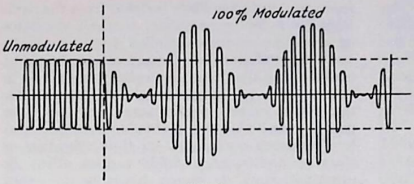

FIG. 3

sides of the carrier frequency in what are called the upper and lower side-bands. At 100% modulation the combined maximum amplitude of the two side-bands is equal to the carrier amplitude, or the maximum amplitude of one side-band is one-half the carrier amplitude. With 100% modulation by a single tone the two side-bands contain one-third of the total average power, while with 100% modulation by speech the two sidebands contain approximately one-fifth of the total average power.

166. (a) With 100% amplitude modulation, what is the ratio of peak current to unmodulated carrier amplitude? (b) What is the ratio of peak power to unmodulated carrier power?

(a) Since the amplitude of a wave modulated 100% varies between zero and twice the unmodulated carrier amplitude, the peak current is twice the unmodulated carrier current. (b) Since power varies as the square of the current, the peak power is four times the unmodulated carrier power. However, the *average* power with 100% modulation by a single-tone signal is 1.5 times the unmodulated carrier power, and with 100% modulation by speech the *average* power is approximately 1.25 times the unmodulated carrier power.

Methods of Modulation

167. Draw a simple schematic diagram of the modulated amplifier and the modulator employing the constant-current (Heising) Class-A system using a single modulator tube, capable of 100% modulation, and briefly explain its operation.

The diagram is shown in Fig. 4-A. The plate power for the modulator tube and modulated amplifier is furnished from a common source through the modulation choke, *L*, which has high impedance for audio frequencies. When the grid circuit of the modulator tube is excited at audio frequency, the modulator operates as a power amplifier with the plate circuit of the Class-C amplifier as its load, the audio output of the modulator being superimposed on the d.c. power supplied to the Class-C amplifier. The r.f. output of the Class-C amplifier is therefore identically modulated. For 100% modulation the audio voltage applied to the Class-C amplifier plate circuit across the choke, *L*, must have a peak value equal to the d.c. voltage on the modulated amplifier. To obtain this without distortion, the d.c. plate voltage on the amplifier must be dropped to a certain value that is less than the modulator plate voltage. The necessary drop in voltage is provided by the resistor *R*, which is by-passed for audio frequencies by the condenser *C*.

168. Draw a simple schematic diagram of the modulated amplifier and the modulator employing a Class-B balanced modulator, capable of 100% modulation, and briefly explain its operation.

The diagram is shown in Fig. 4-B. The output of the Class-B modulator is coupled to the plate circuit of the modulated amplifier through the transformer *T*. The plate current for the modulated amplifier flows through the secondary of

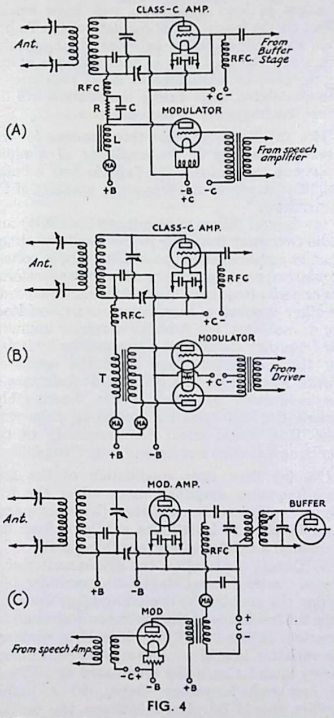

FIG. 4

In Fig. 4 (C), the input transformer to the modulator should have an iron core, indicated in the same fashion as for the output transformer.

T. When the grids of the Class-B modulator tubes are properly excited, the audio-frequency power developed in the plate circuit is combined with the d.c. plate power of the modulated amplifier stage through the medium of the coupling transformer, thus varying the power input and output of the modulated amplifier in accordance with the input signal variations. For 100% modulation the turns ratio of the coupling transformer must be such that the instantaneous voltage at the plate of the modulated amplifier can vary between zero and twice the d.c. operating plate voltage.

169. Draw a simple schematic diagram of the modulated amplifier and the modulator in the grid-bias system of modulation, capable of 100% modulation, and briefly explain its operation.

The diagram is shown in Fig. 4-C. In the grid-bias system of modulation, the secondary of an audio-frequency output transformer, whose primary is in the plate circuit of the modulator tube, is connected in series with the grid-bias supply for the modulated amplifier. When the grid bias and radio-frequency excitation to the modulated amplifier are properly adjusted, the power output will vary in accordance with the audio-frequency voltage variations set up in the grid circuit by the modulator tube. In this method of modulation the modulator tube does not furnish power to the modulated stage. The efficiency of the modulated stage is low because for 100% modulation it must have sufficient capacity to supply power peaks four times as great as the carrier power, and therefore is working far below its capabilities when no modulation is taking place.

170. Draw a simple schematic diagram of the modulated amplifier and the modulator employing a Class-A (push-pull) balanced modulator, capable of 100% modulation, and briefly explain its operation.

The diagram is the same as that for the Class-B modulator shown in Fig. 4-B, but the operating conditions are different. The output of the push-pull Class-A modulator is transformer-coupled to the plate circuit of the modulated amplifier. When the grids of the modulator tubes are excited, the audio-frequency power generated in the plate circuit is combined with the d.c. power in the modulated-amplifier plate circuit by transfer through the coupling transformer, *T*. The power output of the modulated amplifier varies exactly with the power input to its plate, and the carrier power is therefore varied in accordance with the signal at the grids of the modulator tubes. For 100% modulation the turns ratio of the coupling transformer must be such that the voltage at the plate of the modulated amplifier varies between zero and twice the d.c. operating plate voltage.

Frequency Stability

171. What design features in the transmitter are necessary to prevent frequency modulation?

Modulation should take place in a radio-frequency amplifier stage isolated from the oscillator by a buffer amplifier; a stable oscillator such as the crystal-controlled type should be used; the oscillator plate-supply voltage should be constant and unaffected by voltage variations in other stages; r.f. amplifiers should be perfectly neutralized or screen-grid amplifiers should be used; the oscillator circuit should be isolated from low-frequency equipment so that vibration or stray audio-frequency fields cannot affect its operation; amplifier stages should be prevented from feeding back r.f. energy to the oscillator circuit, either by the use of adequate r.f. filters or shielding, or both.

172. (a) Why is it desirable to use only a small part of the oscillator r.f. power output to excite the first r.f. amplifier? (b) Why is it desirable to use a buffer amplifier?

(a) Because the frequency stability is better with the oscillator lightly loaded and because changes in load conditions will have smaller effect on the frequency of oscillation. (b) To provide sufficient isolation between the modulated stage and the oscillator so that changes in load represented by variations in input resistance of the modulated tube during modulation will not affect the frequency of the oscillator.

173. (a) Name at least three causes for frequency instability in the oscillator of a radiotelephone transmitter. (b) Explain how a buffer amplifier improves the frequency stability of the transmitter.

(a) Several causes of frequency instability are: radio-frequency feedback to the oscillator circuit from an amplifier stage; poor plate-supply voltage regulation; mechanical vibration from transformers or audio-frequency choke coils; defective tube or other apparatus; loose connections; overloading of oscillator. (b) A buffer amplifier improves the frequency stability of a transmitter by isolating the modulated stage from the oscillator. During modulation, the grid-circuit resistance of the modulated amplifier varies considerably, making the load upon the preceding stage variable. This would affect the frequency of the oscillator if it were not for the buffer amplifier.

174. (a) How does modulation of the first radio-frequency amplifier stage affect the frequency stability of the oscillator? (b) What means could be used to isolate the oscillator from the modulated amplifier to prevent this effect?

(a) During modulation the grid-circuit resistance of the modulated stage varies considerably, making the load on the preceding stage variable. Since the frequency of the oscillator is affected by variations in the load into which it is working, this variation in grid resistance will result in frequency modulation if the modulated amplifier is the first radio-frequency stage. (b) A buffer amplfier should be placed between the oscillator and the modulated amplifier to prevent this effect.

Classes of Amplifiers

175. Define and describe the operation of a Class-A audio-frequency amplifier or modulator.

A Class-A audio-frequency amplifier is one whose plate output is an undistorted reproduction of the grid input signal. The grid is biased so that operation is over the linear part of the grid-voltage plate-current curve, and usually the grid excitation is limited so that the grid never has a positive potential with respect to the filament. The average (d.c.) plate current is constant during operation.

176. Define and describe the operation of a Class-B audio-frequency amplifier or modulator.

A Class-B audio-frequency amplifier is one whose plate output per tube is half-waves of the grid input. Two tubes are used in a balanced or push-pull circuit so that undistorted output is obtained from the secondary of the output transformer. The grid bias voltage is adjusted practically to cut-off value so that very little plate current flows when there is no excitation. During excitation the grids may be swung positive so that a driving source of some power capabilities is required.

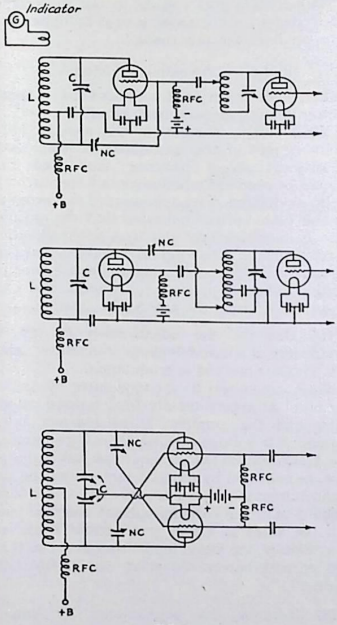

FIG. 5

177. Define and describe the operation of a Class-C radio-frequency amplifier.

A Class-C amplifier is one whose plate power output is proportional to its plate power input; in other words, the power output is proportional to the square of the plate voltage. This makes it useful as an r.f. power amplifier with plate modulation. The Class-C amplifier is operated with grid bias approximately twice that required to cut off the plate current with no excitation. High grid excitation is required so that the output will increase linearly with plate voltage up to twice the normal d.c. voltage. The r.f. harmonics in the output circuit are largely eliminated by the fly-wheel effect of the tuned tank circuit.

178. Define and describe the operation of a Class-B linear radio-frequency amplifier.

A Class-B or linear radio-frequency amplifier is one whose plate power output is proportional to the square of the exciting grid voltage. This makes it useful as a linear amplifier of modulated radio-frequency power. The grid is biased practically to cut-off so that very little plate current flows at zero excitation; the output therefore consists of half-waves of radio-frequency. Operation is over the linear part of the grid-voltage plate-current curve. Because of the fly-wheel effect of the tuned tank circuit, radio-frequency harmonics are largely eliminated and the output wave is essentially of sine shape.

Exciting Stages

179. Draw a schematic circuit diagram illustrating one method of neutralizing a triode radio-frequency buffer amplifier and describe the neutralizing adjustment.

Several neutralizing methods are shown in Fig. 5. The neutralizing adjustment is the same in all, and is as follows: With the neutralizing condenser at any random setting, and with the plate voltage disconnected from the stage to be neutralized, swing the tank condenser C over its scale until maximum radio-frequency current flows in the L-C circuit. The indicating device may be a thermo-galvanometer in series with the tank circuit or inductively coupled to the tank by a loop of wire, a neon glow lamp, or a flashlight bulb connected to a loop of wire coupled inductively to L. Readjust the tank tuning of the preceding stage and turn the neutralizing condenser, NC, in the direction which decreases the r.f. current in LC, if possible carrying the adjustment to the setting at which no current flows. Now readjust C and the preceding-stage tank condenser for resonance. If current again flows in L-C, reset NC for zero current. This process is carried on until there is no indication of r.f. current in L-C when both L-C and the preceding stage are tuned to resonance, at which point the buffer stage is neutralized.

180. (a) Explain how a frequency-doubling amplifier using a three-element vacuum tube should be adjusted for most effective operation.

(b) How is the plate current of a buffer amplifier affected when the plate tank circuit is tuned to resonance?

(a) A frequency-doubling amplifier should be operated with the grid biased considerably beyond the plate-current cut-off point and with high excitation, to accentuate the harmonic output. A high *L-C* ratio in the plate tank circuit also is helpful. (b) The plate current decreases when the plate tank circuit is tuned to resonance if the buffer amplifier is operating properly.

181. What precautions should be taken in the adjustment of a frequency-doubling stage to insure that its output circuit is tuned to the desired harmonic frequency?

The constants of the inductance and capacity in the plate tank circuit should be properly chosen to resonate at the desired frequency, and the frequency should be measured with an absorption wavemeter.

182. How can you determine that a crystal-controlled oscillator will operate on only the desired frequency?

The oscillator should be started and the signal tuned in on an oscillating monitor. Then the plate voltage should be shut off and re-applied; next, the tank condenser should be swung completely through the resonance setting so that the oscillator stops working and then should be retuned for oscillation. If the oscillator always operates on the same frequency during these two tests it is probable that the crystal has only one frequency. A further test would be to allow the oscillator to operate for a considerable period of time to ascertain whether heating of the crystal will cause the frequency to "jump".

Audio

183. What adjustments of a Class-A speech amplifier should be made if the plate current increases with excitation?

This may be an indication either of improper grid bias or excessive excitation. In the first case, the negative grid bias should be reduced; in the second, the grid excitation should be decreased.

184. What adjustments of a Class-A speech amplifier should be made if the plate current decreases with excitation?

A decrease in plate current indicates that the grid of the tube is being driven positive when the exciting grid voltage is delivered by a high-impedance source such as a voltage amplifier. Either the excitation should be reduced so that the driving stage is not overloaded, or, if the tube has been improperly biased, the negative bias should be increased to set the grid potential at the correct operating point.

185. Name three causes of distortion in the speech amplifier of a radiotelephone transmitter and describe the adjustment to overcome each.

Causes of distortion in the speech amplifier could be: (a) incorrect biasing of amplifiers; (b) excessive excitation, causing overloading of tubes; (c) audio-frequency feedback, between stages, causing howling or accentuation of a small band of frequencies; (d) audio degeneration, causing loss of amplification at the lower frequencies; (e) radio-frequency feedback, or r.f. pickup in the speech amplifier, causing tube overloading; (f) improper choice of tubes for the speech amplifier, particularly in the last stages, resulting in overloading at high modulation levels.

The respective adjustments to correct these faults would be: (a) use grid bias which sets the grid potential at the correct operating point; (b) reduce excitation by means of gain control; (c) install decoupling networks; (d) use by-pass condensers of adequate size across cathode resistor or grid-bias source; (e) shield speech amplifier and install r.f. filters; (f) use tubes capable of handling without distortion the signal voltages required.

186. If the plate milliammeter of the speech amplifier indicates distortion by fluctuating with input, and if the grid bias and the plate voltage are of proper values, what adjustment should be made to eliminate distortion?

The exciting grid voltage to the tube whose plate current is fluctuated should be reduced by turning down the gain control.

Modulated Amplifier and Modulator

187. How can it be determined that a transmitter is being properly modulated?

With proper modulation, the average (d.c.) plate current of the modulated r.f. stage (and subsequent stages handling modulated r.f.) should be constant whether or not the carrier is being modulated. Variation upward or downward in this plate current indicates that the modulation is unsymmetrical and that overmodulation is taking place. With a pure sine-wave modulating signal, for 100% modulation the effective antenna current indicated by the r.f. ammeter should increase 22.5% from the unmodulated value.

188. Describe the adjustments for proper modulation of a radiotelephone transmitter using the grid-bias method of modulation.

The negative bias on the modulated r.f. amplifier is set at approximately 50% beyond cut-off value and the amplifier is neutralized. With normal plate voltage applied, the r.f. grid excitation is adjusted so that grid current just begins to flow, as indicated by the grid meter, and the antenna current is noted. The grid excitation is then reduced until the antenna current becomes one-half the value at which grid current began to flow. Finally, the audio input is adjusted so that grid current barely shows on the modulation peaks.

189. Describe the adjustments for proper modulation of a radiotelephone transmitter using

single-tube Class-A plate modulation of a Class-C radio-frequency amplifier.

The Class-C amplifier is neutralized, and the input and output circuits are tuned to resonance with normal plate voltage applied. The coupling to the antenna (load) circuit is then adjusted so that the Class-C amplifier plate current is of the correct value to load the modulator tube properly, the value of this load resistance in ohms being equal to the Class-C amplifier plate voltage divided by the Class-C amplifier plate current in amperes. Since the d.c. milliammeter reads the sum of the modulator and modulated-amplifier plate currents, the current taken by the modulator must be subtracted from the meter reading to obtain the true value of the Class-C amplifier plate current. With sustained sound input to the microphone, the gain control of the speech amplifier is set just below the point at which the plate current shows variation with maximum modulation.

190. Describe the adjustments for proper modulation of a radiotelephone transmitter using a Class-B balanced modulator to modulate a Class-C radio-frequency amplifier.

The procedure of adjusting the Class-C amplifier is the same as described in the answer to the preceding question, except that the plate milliammeter can be inserted readily in the circuit so that it reads the plate current of the Class-C amplifier alone. The speech-amplifier gain control should be set so that proper plate current is obtained in the Class-B modulator stage, or just below the point at which the Class-C amplifier plate current shows variation at maximum modulation with sustained sound input to the microphone.

Frequency Modulation

191. What are three likely causes of frequency modulation?

Likely causes of frequency modulation are variation in oscillator plate voltage when a common transmitter plate supply having poor regulation is used; reaction on the oscillator as the result of improper neutralization of an amplifier; modulated r.f. feedback to the oscillator; and vibration of the oscillator by an audio transformer or choke.

192. What are the undesirable effects of frequency modulation?

Because of the spurious side-band frequencies generated by frequency modulation, the received signal is distorted and the wave is broad, causing serious interference.

193. Name three precautions to prevent frequency modulation.

Some precautions to prevent frequency modulation are: a stable oscillator such as the crystal-controlled type should be used; the oscillator plate-supply voltage should be constant; a buffer amplifier should be used; r.f. amplifiers should be perfectly neutralized; and the oscillator circuit should be isolated from low-frequency equipment and should be shielded if necessary.

194. Describe a method of checking the emission for frequency modulation.

The transmitted wave is tuned in on a listening monitor and heterodyned either by an oscillating detector or by a separate oscillator such as a heterodyne frequency meter. At zero beat the modulation will sound clear and distinct if there is no frequency modulation. If there is frequency modulation the signal will sound "mushy" and be badly distorted. With severe frequency modulation the signal will be unintelligible.

Overmodulation

195. What are the undesirable effects of overmodulation and how should it be prevented?

Overmodulation causes audio-frequency distortion of the received signal and a broad interfering wave. Overmodulation can be prevented by using the correct amount of modulator power to modulate the plate input to the Class-C amplifier, by providing sufficient excitation for the Class-C amplifier, and by adjusting the Class-C amplifier plate voltage and plate current to provide the proper load resistance for the modulator. If a Class-B linear r.f. amplifier is used, overmodulation can be prevented by proper adjustment of the antenna coupling and r.f. grid excitation, provided the modulation is linear in the preceding stages. In the grid-bias method of modulation, overmodulation can be prevented by proper adjustment of r.f. grid excitation and bias, and by keeping the audio grid voltage within proper limits. In all these systems, variation in d.c. plate current of a modulated r.f. stage is an indication of overmodulation; the adjustments should be made to the end that the plate current has the same value when modulated as when unmodulated.

196. What are the likely causes of overmodulation and how should it be prevented?

The most likely cause of overmodulation is the use of excessive modulator power so that the modulated r.f. amplitude increases above the unmodulated value more than it decreases below it. Unequal upward and downward modulation may occur as the result of overloading the speech amplifier or the modulator, insufficient Class-C amplifier excitation, improper modulator bias, or improper adjustment of a Class-B linear r.f. amplifier. Preventive means are discussed in the answer to the preceding question.

197. What are the sources of radiotelephone interference with broadcast reception and what are the precautions to prevent it?

Frequency modulation and overmodulation are the two most likely causes of interference with broadcast reception. Means of preventing frequency modulation and overmodulation have been discussed in previous questions. If the transmitter is free from both, the interference probably

is attributable to insufficient selectivity in the broadcast receiver, or insufficient shielding in the receiver, especially in the case of superheterodynes, which can pick up interference because of beats between amateur signals and oscillator harmonics. If the affected broadcast receiver is deficient in selectivity, a wave-trap, tuned to the transmitter frequency and connected in the receiver lead-in, will minimize interference. A reduction in interference may also be effected by changing the relative positions of the transmitting and receiving antennas.

198. How can you determine whether or not there is overmodulation by observation of a current-indicating meter in the transmitter?

Overmodulation can be detected by observing the plate-current milliammeter in the modulated stage or plate meters in linear stages following the modulated stage. If the plate currents on such stages show no change with modulation, the transmitter is properly modulated; if the plate currents vary with modulation, the carrier is being overmodulated.

Extracts from the Communications Law

The complete text of the Communications Act of 1934, would occupy many pages. Only those parts most applicable to amateur radio station licensing and regulation in this country (with which every amateur should be familiar) are given. Note particularly Secs. 324, 325, 326 and 605 and the penalties provided in Secs. 501 and 502.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, and for the purpose of securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is hereby created a commission to be known as the "Federal Communications Commission," which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this Act.

SEC. 2. (a) The provisions of this Act shall apply to all interstate and foreign communication by wire or radio and all interstate and foreign transmission of energy by radio, which originates and/or is received within the United States, and to all persons engaged within the United States in such communication or such transmission of energy by radio, and to the licensing and regulating of all radio stations as hereinafter provided; but it shall not apply to persons engaged in wire or radio communication or transmission in the Philippine Islands or the Canal Zone, or to wire or radio communication or transmission wholly within the Philippine Islands or the Canal Zone. . . .

SEC. 4. (a) The Federal Communications Commission (in this Act referred to as the "Commission") shall be composed of seven commissioners appointed by the President, by and with the advice and consent of the Senate, one of whom the President shall designate as chairman. . . .

SECTION 301. It is the purpose of this Act, among other things, to maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio (a) from one place in any Territory or possession of the United States or in the District of Columbia to another place in the same Territory, possession, or District; or (b) from any State, Territory, or possession of the United States, or from the District of Columbia to any other State, Territory, or possession of the United States; or (c) from any place in any State, Territory, or possession of the United States, or in the District of Columbia, to any place in any foreign country or to any vessel; or (d) within any State when the effects of such use extend beyond the borders of said State, or when interference is caused by such use or operation with the transmission of such energy, communications, or signals from within said State to any place beyond its borders, or from any place beyond its borders to any place within said State, or with the transmission or reception of such energy, communications, or signals from and/or to places beyond the borders of said State; or (e) upon any vessel or aircraft of the United States; or (f) upon any other mobile stations within the jurisdiction of the United States, except under and in accordance with this Act and with a license in that behalf granted under the provisions of this Act.

SEC. 303. Except as otherwise provided in this Act, the Commission from time to time, as public convenience, interest, or necessity requires, shall—

(a) Classify radio stations;

(b) Prescribe the nature of the service to be rendered by each class of licensed stations and each station within any class;

(c) Assign bands of frequencies to the various classes of stations, and assign frequencies for each individual station and determine the power which each station shall use and the time during which it may operate;

(d) Determine the location of classes of stations or individual stations;

(e) Regulate the kind of apparatus to be used with respect to its external effects and the purity and sharpness of the emissions from each station and from the apparatus therein;

(f) Make such regulations not inconsistent with law as it may deem necessary to prevent interference between stations and to carry out the provisions of this Act: *Provided, however*, That changes in the frequencies, authorized power, or in the times of operation of any station, shall not be made without the consent of the station licensee unless, after a public hearing, the Commission shall determine that such changes will promote public convenience or interest or will serve public necessity, or the provisions of this Act will be more fully complied with;

(g) Study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest; . . .

(j) Have authority to make general rules and regulations requiring stations to keep such records of programs, transmissions of energy, communications, or signals as it may deem desirable; . . .

(l) Have authority to prescribe the qualifications of station operators, to classify them according to the duties to be performed, to fix the forms of such licenses, and to issue them to such citizens of the United States as the Commission finds qualified;

(m) Have authority to suspend the license of any operator for a period not exceeding two years upon proof sufficient to satisfy the Commission that the licensee (1) has violated any provision of any Act or treaty binding on the United States which the Commission is authorized by this Act to administer or any regulation made by the Commission under any such Act or treaty; . . . or (3) has willfully damaged or permitted radio apparatus to be damaged; or (4) has transmitted superfluous radio communications or signals or radio communications containing profane or obscene words or language; or (5) has willfully or maliciously interfered with any other radio communications or signals;

(n) Have authority to inspect all transmitting apparatus to ascertain whether in construction and operation it conforms to the requirements of this Act, the rules and regulations of the Commission, and the license under which it is constructed or operated;

(o) Have authority to designate call letters of all stations;

(p) Have authority to cause to be published such call letters and such other announcements and data as in the judgment of the Commission may be required for the efficient operation of radio stations subject to the jurisdiction of the United States and for the proper enforcement of this Act; . . .

SEC. 309. (a) If upon examination of any application for a station license or for the renewal or modification of a station license the Commission shall determine that public interest, convenience, or necessity would be served by the granting thereof, it shall authorize the issuance, renewal, or modification thereof in accordance with said finding. In the event the Commission upon examination of any such application does not reach such decision with respect thereto, it shall notify the applicant thereof, shall fix and give notice

of a time and place for hearing thereon, and shall afford such applicant an opportunity to be heard under such rules and regulations as it may prescribe.

SEC. 318. The actual operation of all transmitting apparatus in any radio station for which a station license is required by this Act shall be carried on only by a person holding an operator's license issued hereunder. No person shall operate any such apparatus in such station except under and in accordance with an operator's license issued to him by the Commission.

SEC. 321. . . . (b) All radio stations, including Government stations and stations on board foreign vessels when within the territorial waters of the United States, shall give absolute priority to radio communications or signals relating to ships in distress; shall cease all sending on frequencies which will interfere with hearing a radio communication or signal of distress, and, except when engaged in answering or aiding the ship in distress, shall refrain from sending any radio communications or signals until there is assurance that no interference will be caused with the radio communications or signals relating thereto, and shall assist the vessel in distress, so far as possible, by complying with its instructions.

SEC. 324. In all circumstances, except in case of radio communications or signals relating to vessels in distress, all radio stations, including those owned and operated by the United States, shall use the minimum amount of power necessary to carry out the communication desired.

SEC. 325. (a) No person within the jurisdiction of the United States shall knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent signal of distress, or communication relating thereto, nor shall any broadcasting station rebroadcast the program or any part thereof of another broadcasting station without the express authority of the originating station. . . .

SEC. 326. Nothing in this Act shall be understood or construed to give the Commission the power of censorship over the radio communications or signals transmitted by any radio station, and no regulation or condition shall be promulgated or fixed by the Commission which shall interfere with the right of free speech by means of radio communication. No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

SEC. 501. Any person who willfully and knowingly does or causes or suffers to be done any act, matter, or thing, in this Act prohibited or declared to be unlawful, or who willfully and knowingly omits or fails to do any act, matter, or thing in this Act required to be done, or willfully and knowingly causes or suffers such omission or failure, shall, upon conviction thereof, be punished for such offense, for which no penalty (other than a forfeiture) is provided herein, by a fine of not more than $10,000 or by imprisonment for a term of not more than two years, or both.

SEC. 502. Any person who willfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided by law, be punished, upon conviction thereof, by a fine of not more than $500 for each and every day during which such offense occurs.

SEC. 605. No person receiving or assisting in receiving, or transmitting, or assisting in transmitting, any interstate or foreign communication by wire or radio shall divulge or publish the existence, contents, substance, purport, effect, or meaning thereof, except through authorized channels of transmission or reception, to any person other than the addressee, his agent, or attorney, or to a person employed or authorized to forward such communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the communication may be passed, or to the master of a ship under whom he is serving, or in response to a subpena issued by a court of competent jurisdiction, or on demand of other lawful authority; and no person not being authorized by the sender shall intercept any communication and divulge or publish the existence, contents, substance, purport, effect, or meaning of such intercepted communication to any person; and no person not being entitled thereto shall receive or assist in receiving any interstate or foreign communication by wire or radio and use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto; and no person having received such intercepted communication or having become acquainted with the contents, substance, purport, effect, or meaning of the same or any part thereof, knowing that such information was so obtained, shall divulge or publish the existence, contents, substance, purport, effect, or meaning of the same or any part thereof, or use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto: *Provided*, That this section shall not apply to the receiving, divulging, publishing, or utilizing the contents of any radio communication broadcast, or transmitted by amateurs or others for the use of the general public, or relating to ships in distress.

SEC. 606. . . . (c) Upon proclamation by the President that there exists war or a threat of war or a state of public peril or disaster or other national emergency, or in order to preserve the neutrality of the United States, the President may suspend or amend, for such time as he may see fit, the rules and regulations applicable to any or all stations within the jurisdiction of the United States as prescribed by the Commission, and may cause the closing of any station for radio communication and the removal therefrom of its apparatus and equipment, or he may authorize the use or control of any such station and/or its apparatus and equipment by any department of the Government under such regulations as he may prescribe, upon just compensation to the owners.

United States Amateur Regulations

Pursuant to the basic communications law, general regulations for amateurs have been drafted by the Federal Communications Commission. The number before each regulation is its official number in the complete book of regulations for all classes of radio stations as issued by the Commission; since the amateur regulations are not all in one group, the numbers are not necessarily consecutive. The number of each regulation is of no consequence to the amateur, except as a means of reference.

Every amateur should be *thoroughly familiar* with these regulations and their effect, although, of course, it is not necessary to know the exact wording from memory.

RULES AND REGULATIONS GOVERNING AMATEUR RADIO STATIONS

103.6. Each application for an instrument of authorization shall be made in writing, under oath of the applicant, on a form prescribed and furnished by the Commission. . . . Separate application shall be filed for each instrument of authorization requested. . . . The required forms may be obtained from the Commissior or from any of its field offices. (For a list of such offices and related geographical districts, see rule 30.)

103.7. Each application for . . . station license, with respect to the number of copies and place of filing, shall be submitted as follows: . . . g. Amateur . . . 1 copy to be sent as follows: (*a*) To proper district office if it requires personal appearance for operator examination under direct supervision from that office; (*b*) Direct to Washington, D. C., in all other cases, including examinations for class C privileges.

103.14. An application for modification of license may be filed for . . . change in location. . . . Except when filed to cover construction permit, each application for modification of license shall be filed at least 60 days prior to the contemplated modification of license; *Provided, however*, That in emergencies and for good cause shown, the Commission may waive the requirements hereof insofar as time for filing is concerned.

103.15. Unless otherwise directed by the Commission, each application for renewal of license shall be filed at least 60 days prior to the expiration date of the license sought to be renewed.

104.7. If an applicant, by specific request of the Commission, is required to file any documents or information not included in the prescribed application forms, a failure to comply therewith shall constitute a defect in the application, and the application will not be considered by the Commission. Any application which is not filed in accordance with the Commission's regulations with respect to the form used, manner of execution, and completeness of answer to questions therein required, will not be considered by the Commission. Each such application shall be returned to the applicant by the Secretary of the Commission, together with a brief statement of the respect in which it is defective.

105.23. Any licensee receiving official notice of a violation of the terms of the Communications Act of 1934, any legislative act, Executive order, treaty to which the United States is a party or the rules and regulations of the Federal Communications Commission, which are binding upon licensee or the terms and conditions of a license, shall, within 3 days from such receipt, send a written reply direct

to the Federal Communications Commission at Washington, D. C., and a copy thereof to the office of the Commission originating the official notice, when the originating office is other than the office of the Commission in Washington, D. C. The answer to each notice shall be complete in itself and shall not be abbreviated by reference to other communications or answer to other notices. If the notice relates to some violation that may be due to the physical or electrical characteristics of the transmitting apparatus, the answer shall state fully what steps, if any, are taken to prevent future violations, and if any new type apparatus is to be installed, the date such apparatus was ordered, the name of the manufacturer, and promised date of delivery. . . .

If the notice of violation relates to some lack of attention or improper operation of the transmitter, the name and license number of the operator in charge shall be given.

105.29. Whenever the Commission shall institute a revocation proceeding against the holder of any radio station construction permit or license under section 312(a), it shall initiate said proceeding by serving upon said licensee an order of revocation effective not less than 15 days after written notice thereof is given the licensee. The order of revocation shall contain a statement of the grounds and reasons for such proposed revocation and a notice of the licensee's right to be heard by filing with the Commission a written request for hearing within 15 days after receipt of said order. Upon the filing of such written request for hearing by said licensee the order of revocation shall stand suspended and the Commission will set a time and place for hearing and shall give the licensee and other interested parties notice thereof. If no request for hearing on any order of revocation is made by the licensee against whom such an order is directed within the time hereinabove set forth, the order of revocation shall become final and effective, without further action of the Commission. . . .

105.31. Proceedings for the suspension of an operator license shall in all cases be initiated by the entry of an order of suspension, a copy of which shall be served upon or mailed to the holder of the license involved, to become effective on a day certain, in no event less than 40 days after date of serving or mailing such order. The order shall set forth the name of the operator, class and grade of license, the effective date of the order, the period of suspension, and a statement of the reasons for suspension, and shall contain a notice to the holder of such license of his right to be heard and contest the order, by filing with the Commission within 35 days from the receipt of said order, a written request for hearing with a statement executed by him under oath, denying or explaining specifically and in detail the charges set forth in the order of suspension. Upon receipt of such request and statement, the effective date of the suspension of such license will be extended; and the Commission, upon consideration of the licensee's statement, as herein provided, will either revoke its order of suspension, or fix a time and place for hearing, and notify the licensee thereof.

If no request for hearing on any order of suspension is made by the licensee against whom such order is directed within 35 days of receipt of such order of suspension, the same shall become final and effective.

Where any order of suspension has become final, the person whose license has been suspended shall forthwith send the operator's license in question to the office of the Commission in Washington, D. C.

27. All station licenses will be issued so as to expire at the hour of 3 a.m., eastern standard time. The normal license periods and expiration dates are as follows:

(e) The licenses for amateur stations will be issued for a normal license period of three years from the date of expiration of old license or the date of granting a new license or modification of a license.

28. Insofar as practicable, call signals of radio stations will be designated in alphabetical order from groups available for assignment, depending upon the class of station to be licensed. Because of the large number of amateur stations, calls will be assigned hereto in regular order and requests for particular calls will not be considered, except on formal application the Commission may reassign calls to the last holders of record.

29. Call signals of stations will be deleted in each of the following cases:

(a) Where an existing instrument of authorization has expired and no application for renewal or extension thereof has been filed.

(b) Where a license has been revoked.

(c) Where a license is surrendered or cancelled.

(d) Other cause, such as death, loss of citizenship, or adjudged insanity of the station licensee. Such occurrences coming to notice should be reported to the Commission, preferably accompanied by the station license for cancellation, if available.

30. The following list of the radio districts gives the address of each field office of the Federal Communications Commission and the territory embraced in each district. [This list is reproduced on the last page of this booklet. — Ed.]

(a) The following is a list of the cities where examinations will be held for radio operators' licenses in addition to Washington, D. C., and the radio district offices of the Commission. Other cities may also be designated from time to time for the purpose of conducting commercial operators' examinations only: (See Rules 2, 404, and 408.)

Schenectady, N. Y.	St. Louis, Mo.
Winston-Salem, N. C.	Pittsburgh, Pa.
Nashville, Tenn.	Cleveland, Ohio
San Antonio, Tex.	Cincinnati, Ohio
Oklahoma City, Okla.	Columbus, Ohio
Des Moines, Iowa	

Examinations for commercial and Class A amateur privileges will be conducted not more than twice per year in the following cities, which are not to be construed as examining cities under the rules which apply for Class B and C amateur privileges:

Albuquerque, New Mexico	Jacksonville, Florida
Billings, Montana	Little Rock, Arkansas
Bismarck, North Dakota	Phoenix, Arizona
Boise, Idaho	Salt Lake City, Utah
Butte, Montana	Spokane, Washington

188. The term "station" means all of the radio-transmitting apparatus used at a particular location for one class of service and operated under a single instrument of authorization. In the case of every station other than broadcast, the location of the station shall be considered as that of the radiating antenna.

192. The term "portable station" means a station so constructed that it may conveniently be moved about from place to place for communication and that is in fact so moved about from time to time, but not used while in motion.

(a) The term "portable-mobile station" means a station so constructed that it may conveniently be moved from one mobile unit to another for communication, and that is, in fact, so moved about from time to time and ordinarily used while in motion.

204. Allocations of bands of frequencies to services, such as mobile, fixed, broadcast, amateur, etc., are set forth in Article 5 of the General Regulations annexed to the International Radiotelegraph Convention and in the North American Radio Agreement. These allocations will be adhered to in all assignments to stations capable of causing international interference.

207. Licensees shall use radio transmitters, the emissions of which do not cause interference, outside the authorized band, that is detrimental to traffic and programs of other authorized stations.

210. Radio communications or signals relating to ships or aircraft in distress shall be given absolute priority. Upon notice from any station, Government or commercial, all other transmission shall cease on such frequencies and for such time as may, in any way, interfere with the reception of distress signals or related traffic.

215. One or more licensed operators, of grade specified by these regulations, shall be on duty at the place where the transmitting apparatus of each station is located and whenever it is being operated; provided, however, that for a station licensed for service other than broadcast, and remote control is used, the Commission may modify the foregoing requirement upon proper application and showing being made, so that such operator or operators may be on duty at the control station in lieu of the place where the transmitting apparatus is located. Such modification shall be subject to the following conditions:

(a) The transmitter shall be capable of operation and shall be operated in accordance with the terms of the station license.

(b) The transmitter shall be monitored from the control station with apparatus that will permit placing the transmitter in an inoperative condition in the event there is a deviation from the terms of the license, in which case the radiation of the transmitter shall be suspended immediately and corrective measures are effectively applied to place the transmitter in proper condition for operation in accordance with the terms of the station license.

(c) The transmitter shall be so located or housed that it is not accessible to other than duly authorized persons.

214. Only an operator holding a radiotelegraph class of operators' license may manipulate the transmitting key of a manually operated coastal telegraph or mobile telegraph station in the international service; and only a licensed amateur operator may manipulate the transmitting key at a manually operated amateur station. The licensees of other stations operated under the constant supervision of duly licensed operators may permit any person or persons, whether licensed or not, to transmit by voice or otherwise, in accordance with the types of emission specified by the respective licenses.

220. Licensees of stations other than broadcast stations are authorized to carry on such routine tests as may be required for the proper maintenance of the stations, provided, however that these tests shall be so conducted as

not to cause interference with the service of other stations.

221. The original of each station license, except amateur, portable and portable-mobile stations shall be posted by the licensee in a conspicuous place in the room in which the transmitter is located. In the case of amateur, portable, and portable-mobile stations the original license, or a photostat copy thereof, shall be similarly posted or kept in the personal possession of the operator on duty.

(a) The original license of each station operator, except amateur and aircraft radio station operators, and operators of portable and portable-mobile stations, shall be posted in a conspicuous place in the room occupied by such operator while on duty. In the case of an amateur or aircraft radio operator, and operators of portable or portable-mobile stations, the original operator's license shall be similarly posted or kept in his personal possession and available for inspection at all times while the operator is on duty.

(b) When an operator's license cannot be posted because it has been mailed to an office of the Federal Communications Commission for endorsement or other change, such operator may continue to operate stations in accordance with the class of license held, for a period not to exceed sixty days, but in no case beyond the date of expiration of the license.

361. The term "amateur service" means a radio service carried on by amateur stations.

362. The term "amateur station" means a station used by an "amateur," that is, a duly authorized person interested in radio technique solely with a personal aim and without pecuniary interest.

364. The term "amateur radio operator" means a person holding a valid license issued by the Federal Communications Commission who is authorized under the regulations to operate amateur radio stations.

365. The term "amateur radiocommunication" means radiocommunication between amateur radio stations solely with a personal aim and without pecuniary interest.

366. An amateur station license may be issued only to a licensed amateur radio operator who has made a satisfactory showing of ownership or control of proper transmitting apparatus; provided, however, that in the case of a military or naval reserve radio station located in approved public quarters and established for training purposes, but not operated by the United States Government, a station license may be issued to the person in charge of such station who may not possess an amateur operator's license.

(a) An amateur operator's license may be granted to a person who does not desire an amateur station license, provided such applicant waives his right to apply for an amateur station license for ninety days subsequent to the date of application for operator's license.

367. Amateur radio station licenses shall not be issued to corporations, associations, or other organizations; provided, however, that in the case of a bona fide amateur radio society, a station license may be issued to a licensed amateur radio operator as trustee for such society.

368. Licenses for mobile stations and portable-mobile stations will not be granted to amateurs for operation on frequencies below 28,000 kilocycles. However, the licensee of a fixed amateur station may operate portable amateur stations (Rule 192) in accordance with the provisions of Rules 384, 386 and 387; and also portable and portable-mobile amateur stations (Rules 192 and 192a) on authorized amateur frequencies above 28,000 kilocycles in accordance with Rules 384 and 386, but without regard to Rule 387.

370. Amateur stations shall be used only for amateur service, except that in emergencies or for testing purposes they may be used also for communication with commercial or Government radio stations. In addition, amateur stations may communicate with any mobile radio station which is licensed by the Commission to communicate with amateur stations, and with stations of expeditions which may also be authorized to communicate with amateur stations.

371. Amateur stations shall not be used for broadcasting any form of entertainment nor for the simultaneous retransmission by automatic means of programs or signals emanating from any class of station other than amateur.

372. Amateur stations may be used for the transmission of music for test purposes of short duration in connection with the development of experimental radiotelephone equipment.

373. Amateur radio stations shall not be used to transmit or receive messages for hire, nor for communication for material compensation, direct or indirect, paid or promised.

374. The following bands of frequencies are allocated exclusively for use by amateur stations:

1,715 to 2,000 kc.	28,000 to 30,000 kc.
3,500 to 4,000 "	56,000 to 60,000 "
7,000 to 7,300 "	400,000 to 401,000 "
14,000 to 14,400 "	

374a. The licensee of an amateur station may, subject to change upon further order, operate amateur stations on any frequency above 110,000 kilocycles, without separate licenses therefor, provided:

(1) That such operation in every respect complies with the Commission's rules governing the operation of amateur stations in the amateur service.

(2) That records are maintained of all transmissions in accordance with the provisions of Rule 386.

375. All bands of frequencies so assigned may be used for radiotelegraphy, type A-1 emission. Type A-2 emission may be used in the following bands of frequencies only:

28,000 to 30,000 kc.
56,000 to 60,000 "
400,000 to 401,000 "

376. The following bands of frequencies are allocated for use by amateur stations using radiotelephony, type A-3 emission:

1,800 to 2,000 kc.	56,000 to 60,000 kc.
28,000 to 29,000 "	400,000 to 401,000 "

377. Provided the stations shall be operated by a person who holds an amateur operator's license endorsed for class A privileges, an amateur radio station may use radiotelephony, type A-3 emission, in the following additional banda of frequencies:

3,900 to 4,000 kc.	14,150 to 14,250 kc.

378. The following bands of frequencies are allocated for use by amateur stations for television, facsimile, and picture transmission:

1,715 to 2,000 kilocycles
56,000 to 60,000 kilocycles

379. Transmissions by an amateur station may be on any frequency within an amateur band above assigned.

380. An amateur radio station shall not be located upon premises controlled by an alien.

381. Spurious radiations from an amateur transmitter operating on a frequency below 30,000 kilocycles shall be reduced or eliminated in accordance with good engineering practice and shall not be of sufficient intensity to cause interference on receiving sets of modern design which are tuned outside the frequency band of emission normally required for the type of emission employed. In the case of A-3 emission, the transmitter shall not be modulated in excess of its modulation capability to the extent that interfering spurious radiations occur, and in no case shall the emitted carrier be amplitude-modulated in excess of 100 per cent. Means shall be employed to insure that the transmitter is not modulated in excess of its modulation capability. A spurious radiation is any radiation from a transmitter which is outside the frequency band of emission normal for the type of transmission employed, including any component whose frequency is an integral multiple or sub-multiple of the carrier frequency (harmonics and sub-harmonics), spurious modulation products, key clicks and other transient effects, and parasitic oscillations.

382. Licensees of amateur stations using frequencies below 30,000 kilocycles, shall use adequately filtered direct-current power supply for the transmitting equipment, to minimize frequency modulation and to prevent the emission of broad signals.

383. Licensees of amateur stations are authorized to use a maximum power input of one kilowatt to the plate circuit of the final amplifier stage of an oscillator-amplifier transmitter or to the plate circuit of an oscillator transmitter.

384. An operator of an amateur station shall transmit its assigned call at least once during each fifteen minutes of operation and at the end of each transmission. In addition, an operator of an amateur portable or portable-mobile radiotelegraph station shall transmit immediately after the call of the station, the break sign (BT) followed by the number of the amateur call area in which the portable or portable-mobile amateur station is then operating, as for example:

Example 1. Portable or portable-mobile amateur station operating in the third amateur call area calls a fixed amateur station: W1ABC W1ABC W1ABC DE W2DEF BT3 W2DEF BT3 W2DEF BT3 AR.

Example 2. Fixed amateur station answers the portable or portable-mobile amateur station: W2DEF W2DEF W2DEF DE W1ABC W1ABC W1ABCK.

Example 3. Portable or portable-mobile amateur station calls a portable or portable-mobile amateur station: W3GHI W3GHI W3GHI DE W4JKL BT4 W4JKL BT4 W4JKL BT4 AR.

If telephony is used, the call sign of the station shall be followed by an announcement of the amateur call area in which the portable or portable-mobile station is operating.

384a. In the case of an amateur licensee whose station is licensed to a regularly commissioned or enlisted member of the United States Naval Reserve, the Commandant of the naval district in which such reservist resides may authorize in his discretion the use of the call letter prefix "N," in lieu of the prefix "W," or "K," assigned in the license issued by the Commission, provided that such "N" prefix shall be used only when operating in the frequency bands 1715–2000 kilocycles and 3500–4000 kilocycles in accordance with instructions to be issued by the Navy Department.

385. In the event that the operation of an amateur radio station causes general interference to the reception of

broadcast programs with receivers of modern design, that amateur station shall not operate during the hours from 8 o'clock p.m. to 10:30 p.m., local time, and on Sundays from 10:30 a.m. until 1 p.m., local time, upon such frequency or frequencies as cause such interference.

386. Each licensee of an amateur station shall keep an accurate log of station operation to be made available upon request by authorized Government representatives, as:

a. The date and time of each transmission. (The date need only be entered once for each day's operation. The expression "time of each transmission" means the time of making a call and need not be repeated during the sequence of communication which immediately follows; however, an entry shall be made in the log when "signing off" so as to show the period during which communication was carried on.)

b. The name of the person manipulating the transmitting key of a radiotelegraph transmitter or the name of the person operating a transmitter of any other type (type A-3 or A-4 emission) with statement as to type of emission. (The name need only be entered once in the log provided the log contains a statement to the effect that all transmissions were made by the person named except where otherwise stated. The name of any other person who operates the station shall be entered in the proper space for his transmissions.)

c. Call letters of the station called. (This entry need not be repeated for calls made to the same station during any sequence of communication provided the time of "signing off" is given.)

d. The input power to the oscillator, or to the final amplifier stage where an oscillator-amplifier transmitter is employed. (This need be entered only once provided the input power is not changed.)

e. The frequency band used. (This information need be entered only once in the log for all transmissions until there is a change in frequency to another amateur band.)

f. The location of a portable or portable-mobile station at the time of each transmission. (This need be entered only once, provided the location of the station is not changed. However, suitable entry shall be made in the log upon changing location, showing the type of vehicle or mobile unit in which the station is operated, and the approximate geographical location of the station at the time of operation.)

g. The message traffic handled. (If record communications are handled in regular message form, a copy of each message sent and received shall be entered in the log or retained on file for at least one year.)

387. Advance notice of all locations in which portable amateur stations will be operated shall be given by the licensee to the Inspector-in-Charge of the district in which the station is to be operated. Such notices shall be made by letter or other means prior to any operation contemplated and shall state the station call, name of licensee, the date of proposed operation and the approximate locations, as by city, town, or county. An amateur station operating under this rule shall not be operated during any period exceeding thirty days without giving further notice to the Inspector-in-Charge of the radio district in which the station will be operated. This rule does not apply to the operation of portable or portable-mobile amateur stations on frequencies above 28,000 kilocycles authorized to be used by amateur stations. (See Rule 368.)

400. An amateur station may be operated only by a person holding a valid amateur operator's license, and then only to the extent provided for by the class of privileges for which the operator's license is endorsed.

401. Amateur operators' licenses are valid only for the operation of licensed amateur stations, provided, however, any person holding a valid radio operators' license of any class may operate stations in the experimental service licensed for, and operating on, frequencies above 30,000 kilocycles.

402. Amateur station licenses and/or amateur operator licenses may, upon proper application, be renewed provided: (1) the applicant has used his station to communicate by radio with at least three other amateur stations during the three-months period prior to the date of submitting the application, or (2) in the case of an applicant possessing only an operator's license, that he has similarly communicated with amateur stations during the same period. Proof of such communication must be included in the application by stating the call letters of the stations with which communication was carried on and the time and date of each communication. Lacking such proof, the applicant will be ineligible for a license for a period of ninety days. This rule shall not prevent renewal of an amateur station license to an applicant who has recently qualified for license as an amateur operator.

403. There shall be but one main class of amateur operator's license to be known as "amateur class" but each such license shall be limited in scope by the signature of the examining officer opposite the particular class or classes of privileges which apply, as follows:

Class A. Unlimited privileges.

Class B. Unlimited radiotelegraph privileges. Limited in the operation of radiotelephone amateur stations to the following bands of frequencies: 1800 to 2000 kilocycles; 28,000 to 29,000 kilocycles; 56,000 to 60,000 kilocycles; 400,000 to 401,000 kilocycles.

Class C. Same as Class B privileges, except that the Commission may require the licensee to appear at an examining point for a supervisory written examination and practical code test during the license term. Failing to appear for examination when directed to do so, or failing to pass the supervisory examination, the license held will be cancelled and the holder thereof will not be issued another license of the Class C privileges.

404. The scope of examinations for amateur operators' licenses shall be based on the class of privileges the applicant desires, as follows:

Class A. To be eligible for examination for the Class A amateur operator's privileges, the applicant must have been a licensed amateur operator for at least one year and must personally appear at one of the Commission's examining offices, and take the supervisory written examination and code test. (See Rules 2 (2) a, 30 and 408.) Examinations will be conducted at Washington, D. C., on Thursday of each week, and at each radio district office of the Commission on the days designated by the Inspector-in-Charge of such offices. In addition, examinations will be held quarterly in the examining cities listed in Rule 30 on the dates to be designated by the Inspector-in-Charge of the radio district in which the examining city is situated. The examination will include the following:

(a) Applicant's ability to send and receive in plain language messages in the Continental Morse Code (5 characters to the word) at a speed of not less than 13 words per minute.

(b) Technical knowledge of amateur radio apparatus, both telegraph and telephone.

(c) Knowledge of the provisions of the Communications Act of 1934 as amended, subsequent acts, treaties, and rules and regulations of the Federal Communications Commission, affecting amateur licensees.

Class B. The requirements for Class B amateur operator's privileges are similar to those for the Class A, except that no experience is required and the questions on radiotelephone apparatus are not so comprehensive in scope.

Class C. The requirements for Class C amateur operator's privileges shall be the same as for the Class B except the examination will be given by mail. Applicants for Class-C privileges must reside more than 125 miles from the nearest examining point for Class-B privileges, or in a camp of the Civilian Conservation Corps, or be in the regular military or naval service of the United States at a military post or naval station; or be shown by physician's certificate to be unable to appear for examination due to protracted disability.

405. An applicant for any class of amateur operator's privileges who has held a radiotelephone second class operator's license or higher, or an equivalent commercial grade license, or who has been accorded unlimited amateur radiotelephone privileges, within five years of the date of application may only be required to submit additional proof as to code ability and/or knowledge of the laws, treaties, and regulations affecting amateur licensees.

406. An applicant for the Class B or C amateur operator's privileges who has held a radiotelegraph third class operator's license or higher, or an equivalent commercial grade license, or who has held an amateur extra first class license within five years of the date of application may be accorded a license by passing an examination in laws, treaties, and regulations affecting amateur licensees.

407. An applicant for Class C amateur operator's privileges must have his application signed in the presence of a person authorized to administer oaths, by (1) a licensed radiotelegraph operator other than an amateur operator possessing only the Class C privileges or former temporary amateur class license, or (2) by a person who can show evidence of employment as a radiotelegraph operator in the Government service of the United States. In either case the radiotelegraph code examiner shall attest to the applicant's ability to send and receive messages in plain language in the Continental Morse Code (5 characters to the word) at a speed of not less than 13 words per minute. The code certification may be omitted if the applicant can show proof of code ability in accordance with the preceding rule.

408. Forms for amateur station and/or operator license shall be obtained by calling or writing to the Inspector-in-Charge of the radio inspection district in which the applicant resides. Upon completion of the forms they shall be sent back to the same office where the final arrangements will be made for the examination: *Provided*, however, in the case of applicants for the Class C amateur operator's privileges, the forms and examination papers when completed shall be mailed direct to the Federal Communications Commission, Washington, D. C.

409. The percentage that must be obtained as a passing mark in each examination is 75 out of a possible 100. No credit will be given in the grading of papers for experience

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or knowledge of the code. If an applicant answers only the questions relating to laws, treaties, and regulations by reason of his right to omit other subjects because of having held a recognized class of license, a percentage of 75 out of a possible 100 must be obtained on the questions answered.

410. An amateur station license shall be issued so as to run concurrently with the amateur operator's license and both licenses shall run for three years from the date of issuance. If either the station license or the operator's license is modified during the license term, both licenses shall be reissued for the full three-year term, provided, however, if an operator's license is modified only with respect to the class of operator's privileges, the old license may be endorsed in which case the expiration date will not change.

411. Eligibility for re-examination. An applicant who fails examination for amateur privileges may not take another examination for such privileges within ninety days, except that this rule shall not apply to successive examinations at a point named in Rule 30-A.

412. Any attempt to obtain an operator's license by fraudulent means or by attempting to impersonate another, or copying or divulging questions used in examinations, or, if found unqualified or unfit, will constitute a violation of the regulations for which the licensee may suffer suspension of license or be refused a license and/or debarment from further examination for a period not exceeding two years at the discretion of the licensing authority.

413. Any licensee applying for a duplicate license to replace an original which has been lost, mutilated, or destroyed, shall submit an affidavit to the Commission attesting to the facts regarding the manner in which the original was lost. Duplicates will be issued in exact conformity with the original, and will be marked "duplicate" on the face of the license.

414. Licenses are not valid until the oath of secrecy has been executed and the signature of the licensee affixed thereto.

415. All examinations, including the code test, must be written in longhand by the applicant.

U. S. RADIO DISTRICTS

District	*Territory*	*Address, Radio Inspector-in-Charge*
No. 1	The States of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.	Customhouse, Boston, Mass.
No. 2	The counties of Albany, Bronx, Columbia, Delaware, Dutchess, Greene, Kings, Nassau, New York, Orange, Putnam, Queens, Rensselaer, Richmond, Rockland, Schenectady, Suffolk, Sullivan, Ulster and Westchester of the State of New York; and the counties of Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union and Warren of the State of New Jersey.	Federal Building, 641 Washington St., New York, N. Y.
No. 3	The counties of Adams, Berks, Bucks, Carbon, Chester, Cumberland, Dauphin, Delaware, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Perry, Philadelphia, Schuylkill and York of the State of Pennsylvania; and the counties of Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean and Salem of the State of New Jersey; and the county of Newcastle of the State of Delaware.	Room 1200, U. S. Customhouse, Second and Chestnut Sts., Philadelphia, Pa.
No. 4	The State of Maryland; the District of Columbia; the counties of Arlington, Clark, Fairfax, Fauquier, Frederick, Loudoun, Page, Prince William, Rappahannock, Shenandoah and Warren of the State of Virginia; and the counties of Kent and Sussex of the State of Delaware.	Fort McHenry, Baltimore, Md.
No. 5	The State of Virginia except that part lying in District 4, and the State of North Carolina except that part lying in District 6.	402 New Post Office Bldg., Norfolk, Va.
No. 6	The States of Alabama, Georgia, South Carolina, and Tennessee; and the counties of Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Cleveland, Graham, Haywood, Henderson, Jackson, McDowell, Macon, Madison, Mitchell, Polk, Rutherford, Swain, Transylvania, Watauga and Yancey of the State of North Carolina.	411 New Post Office Bldg., Atlanta, Ga.
No. 7	The State of Florida, Puerto Rico, and the Virgin Islands.	P. O. Box 150, Miami, Fla.
No. 8	The States of Arkansas, Louisiana and Mississippi; and the city of Texarkana in the State of Texas.	Customhouse, New Orleans, La.
No. 9	The counties of Arkansas, Brazoria, Brooks, Calhoun, Cameron, Chambers, Fort Bend, Galveston, Goliad, Harris, Hidalgo, Jackson, Jefferson, Jim Wells, Kenedy, Kleberg, Matagorda, Nueces, Refugio, San Patricio, Victoria, Wharton and Willacy of the State of Texas.	209 Prudential Building, Galveston, Tex.
No. 10	The State of Texas except that part lying in District 9 and in the city of Texarkana; and the States of Oklahoma and New Mexico.	464 Federal Building, Dallas, Tex.
No. 11	The State of Arizona; the county of Clarke in the State of Nevada; and the counties of Imperial, Inyo, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara and Ventura of the State of California.	1105 Rives-Strong Building, Los Angeles, Calif.
No. 12	The State of California except that part lying in District 11; the State of Nevada except the county of Clarke; the Hawaiian Islands, Guam and American Samoa.	Customhouse, San Francisco, Calif.
No. 13	The State of Oregon; and the State of Idaho except that part lying in District 14.	207 New U. S. Courthouse Bldg., Portland, Ore.
No. 14	The Territory of Alaska; the State of Washington; the counties of Benewah, Bonner, Boundary, Clearwater, Idaho, Kootenai, Latah, Lewis, Nez Perce and Shoshone of the State of Idaho; the counties of Beaverhead, Broadwater, Cascade, Deerlodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis & Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Pondera, Powell, Ravalli, Sanders, Silver Bow, Teton and Toole of the State of Montana.	808 Federal Office Building, Seattle, Wash.
No. 15	The States of Colorado, Utah and Wyoming; and the State of Montana except that part lying in District 14.	538 Customhouse, Denver, Colo.
No. 16	The States of North Dakota, South Dakota and Minnesota; the counties of Alger, Baraga, Chippewa, Delta, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Luce, Mackinac, Marquette, Menominee, Ontonagon and Schoolcraft of the State of Michigan; and the State of Wisconsin except that part lying in District 18.	927 New P. O. Bldg., St. Paul, Minn.
No. 17	The States of Nebraska, Kansas and Missouri; and the State of Iowa except that part lying in District 18.	410 Federal Building, Kansas City, Mo.
No. 18	The States of Indiana and Illinois; the counties of Allamakee, Buchanan, Cedar, Clayton, Clinton, Delaware, Des Moines, Dubuque, Fayette, Henry, Jackson, Johnson, Jones, Lee, Linn, Louisa, Muscatine, Scott, Washington and Winneshiek of the State of Iowa; the counties of Columbia, Crawford, Dane, Dodge, Grant, Green, Iowa, Jefferson, Kenosha, Lafayette, Milwaukee, Ozaukee, Racine, Richland, Rock, Sauk, Walworth, Washington and Waukesha of the State of Wisconsin.	2022 Engineering Building, Chicago, Ill.
No. 19	The State of Michigan except that part lying in District 16; the States of Ohio, Kentucky and West Virginia.	10th Floor, New Federal Bldg., Detroit, Mich.
No. 20	The State of New York except that part lying in District 2, and the State of Pennsylvania except that part lying in District 3.	514 Federal Building, Buffalo, N. Y.
No. 21	The Territory of Hawaii	Aloha Tower, Honolulu, T. H.